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Higashi et al.

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(54) **IMAGE FORMING APPARATUS CAPABLE OF ACCURATELY ESTIMATING POWER CONSUMPTION LEVEL**

(71) Applicant: **KONICA MINOLTA, INC.**, Chiyoda-ku (JP)

(72) Inventors: **Natsuyo Higashi**, Toyokawa (JP); **Shigetaka Kato**, Shinshiro (JP); **Hideki Nakamura**, Hachioji (JP); **Katsufumi Suzuki**, Okazaki (JP); **Hirotada Seki**, Toyokawa (JP)

(73) Assignee: **KONICA MINOLTA, INC.**, Chiyoda-Ku, Tokyo (JP)

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G03G 15/00 (2006.01)

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USPC 399/69
See application file for complete search history.

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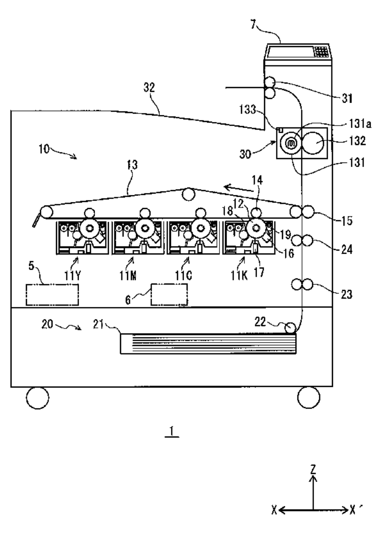
Primary Examiner — Clayton E Laballe
Assistant Examiner — Kevin Butler
(74) *Attorney, Agent, or Firm* — Buchanan Ingersoll & Rooney PC

(57) **ABSTRACT**

An image forming apparatus that heat-fixes a toner image onto a recording sheet passing through a fixing nip formed by pressing a pressurizing member against a heating rotational body heated by a heater, comprising: a storage unit storing a basic power consumption level of the heater determined in advance in a situation where inflow of inrush current to the heater is not occurring; an estimation unit calculating an estimated power consumption level of the heater by estimating an increase in the power consumption level, with respect to the basic power consumption level, brought about by inflow of inrush current to the heater; and an output unit outputting the estimated power consumption level. The heater switches between a heating state of receiving power supply and a non-heating state of not receiving power supply. The increase is estimated according to a duration of a non-heating state immediately preceding the heating state.

18 Claims, 11 Drawing Sheets



(52) **U.S. Cl.**
CPC *G03G15/2078* (2013.01); *G03G 15/2082* (2013.01); *G03G 2215/2016* (2013.01); *G03G 2215/2032* (2013.01)

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FIG. 1

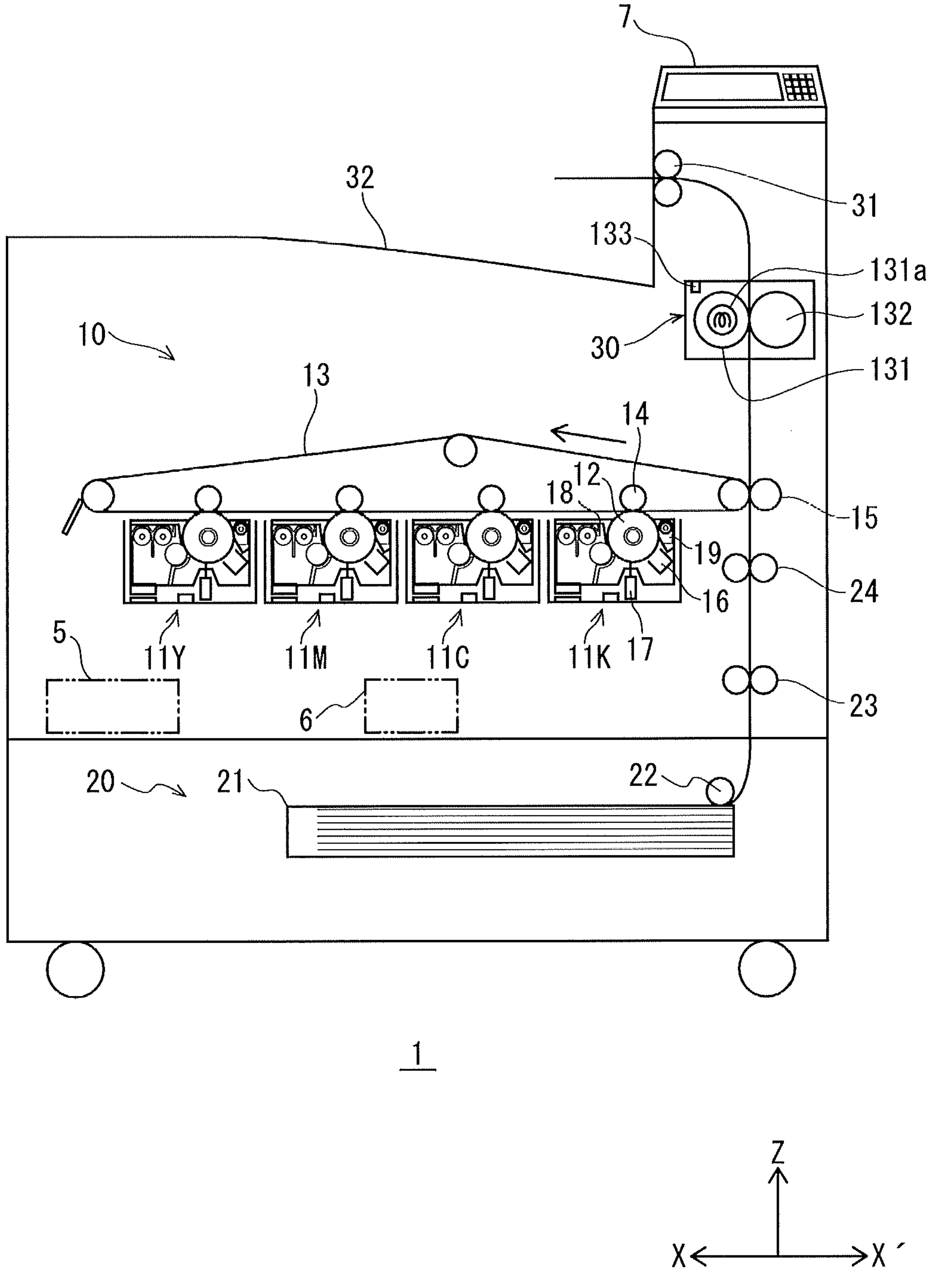

7
32
31
133
131a
132
30
131
10
13
14
12
18
15
19
24
16
17
5
11Y
11M
11C
11K
23
6
20
21
22
1
Z
X
X´

FIG. 2

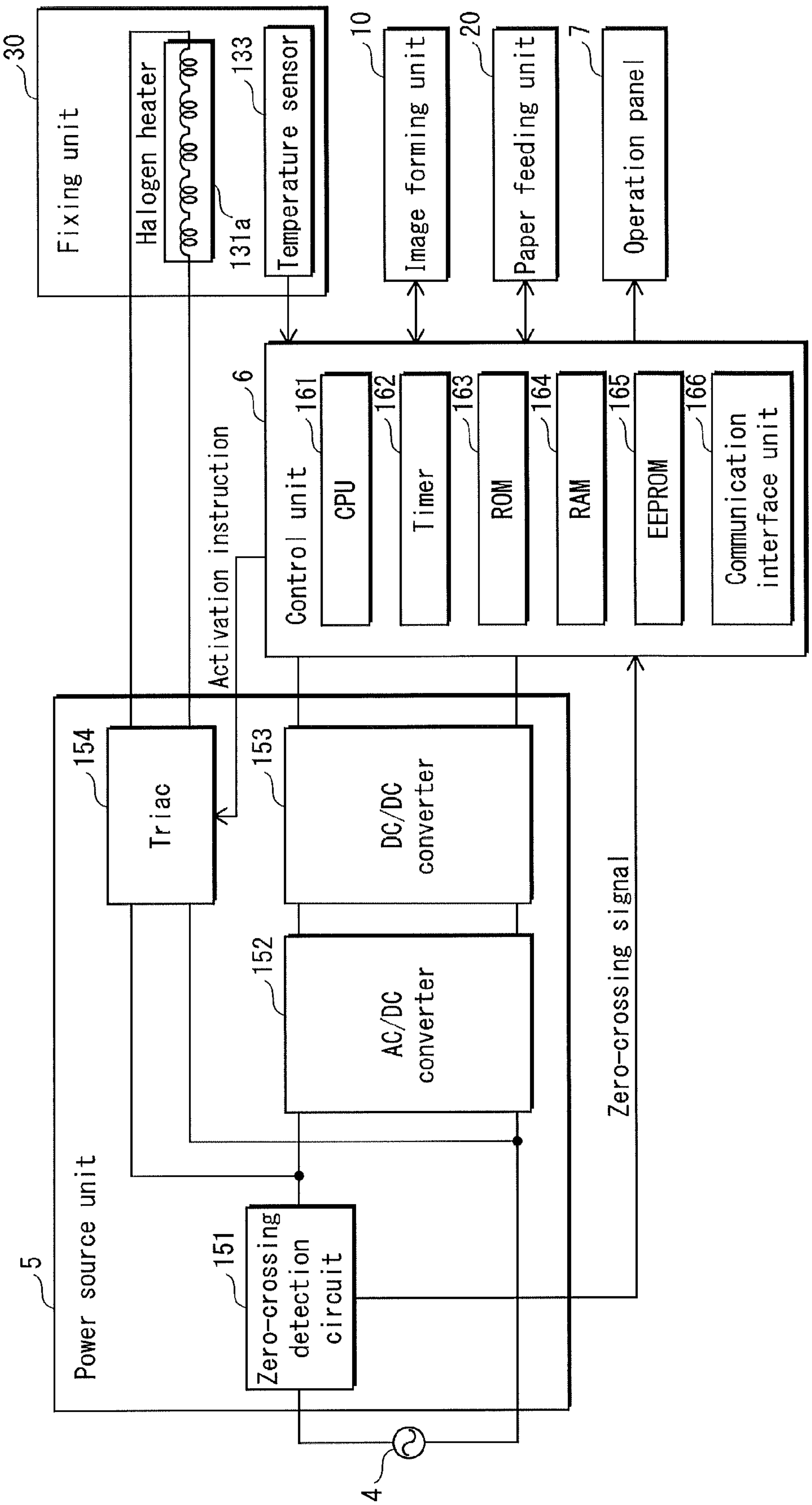
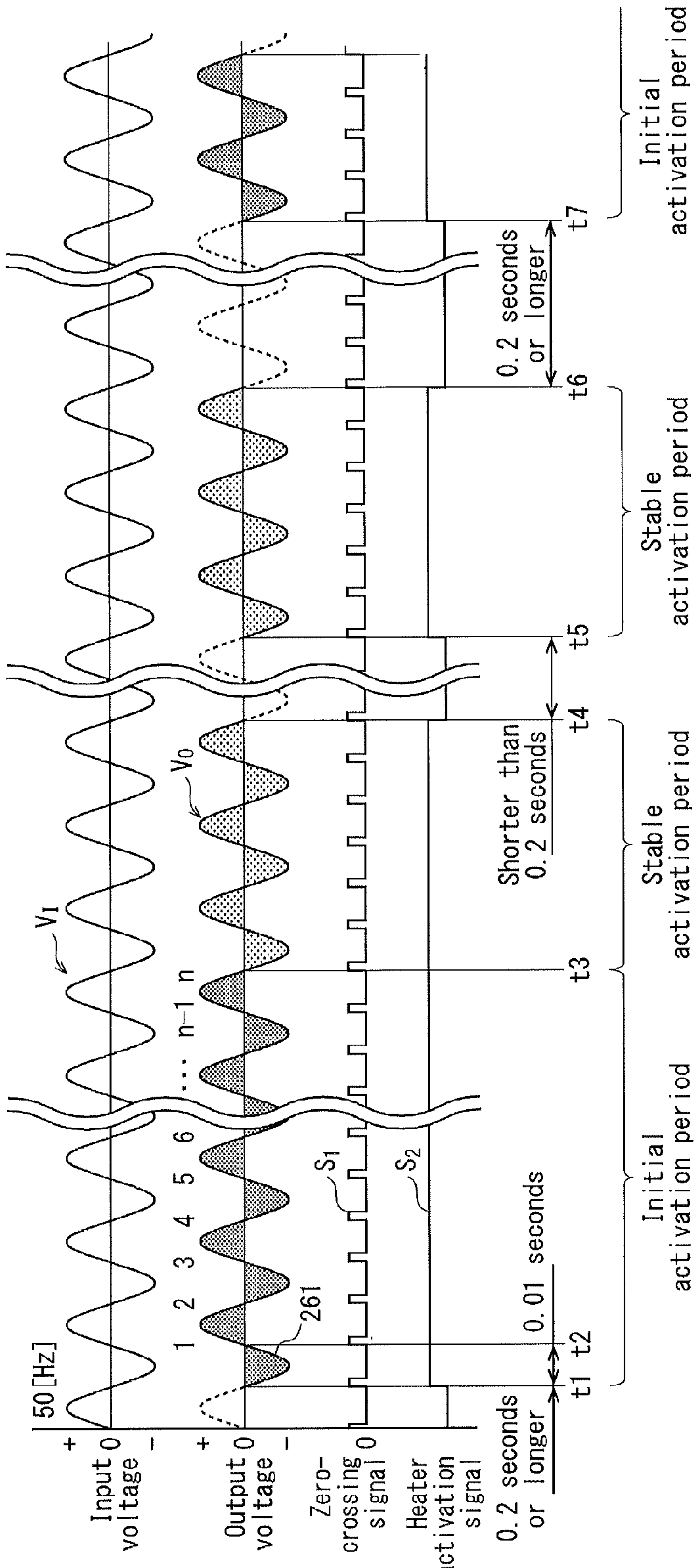

30
Fixing unit
Halogen heater
131a
133
Temperature sensor
10
Image forming unit
20
Paper feeding unit
7
Operation panel
6
Control unit
161
CPU
162
Timer
163
ROM
164
RAM
165
EEPROM
166
Communication interface unit
Activation instruction
5
Power source unit
154
Triac
153
DC/DC converter
152
AC/DC converter
151
Zero-crossing detection circuit
Zero-crossing signal
4

FIG. 3



Input voltage
Output voltage
Zero-crossing signal
Heater activation signal
0.2 seconds or longer
50[Hz]
+
0
−
V_I
V_O
261
S_1
S_2
1 2 3 4 5 6 … n−1 n
t1 t2 t3 t4 t5 t6 t7
0.01 seconds
Shorter than 0.2 seconds
0.2 seconds or longer
Initial activation period
Stable activation period
Stable activation period
Initial activation period

FIG. 4

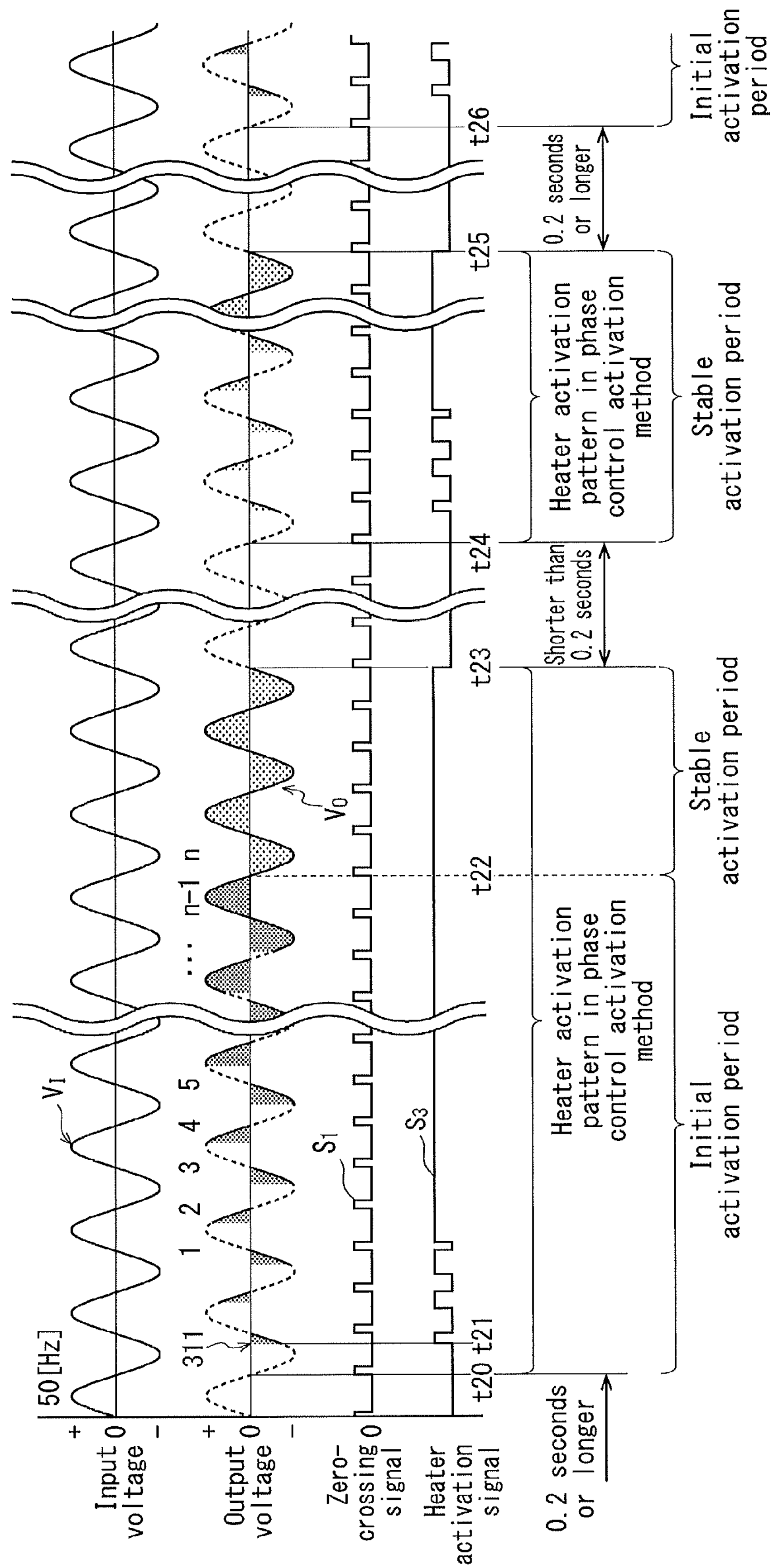
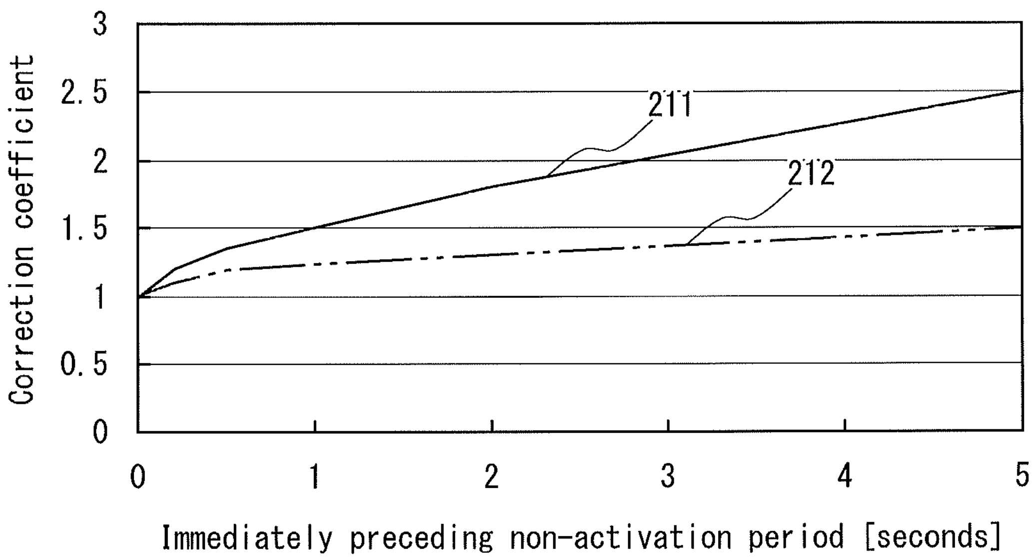

Input voltage
+
0
−
50[Hz]
V_I
Output voltage
+
0
−
311
1 2 3 4 5 … n−1 n
V_O
Zero-crossing signal
0
S_1
Heater activation signal
S_3
t20 t21 t22 t23 t24 t25 t26
0.2 seconds or longer
Heater activation pattern in phase control activation method
Initial activation period
Stable activation period
Shorter than 0.2 seconds
Heater activation pattern in phase control activation method
Stable activation period
0.2 seconds or longer
Initial activation period

FIG. 5



3
2.5
2
1.5
1
0.5
0
Correction coefficient
211
212
0
1
2
3
4
5
Immediately preceding non-activation period [seconds]

FIG. 6A

Correction table A
(zero-crossing control activation method)

221	Immediately preceding non-activation period	0.0 seconds or longer and shorter than 0.2 seconds	0.2 seconds or longer and shorter than 0.5 seconds	0.5 seconds or longer and shorter than 1.0 seconds	1.0 seconds or longer and shorter than 2.0 seconds	2.0 seconds or longer and shorter than 5.0 seconds	5.0 seconds or longer and shorter than … seconds	...	600 seconds or longer (warm-up)
222	Correction coefficient	1.00	1.20	1.35	1.50	1.80	2.50	...	4.20

FIG. 6B

Correction table B
(phase control activation method)

231	Immediately preceding non-activation period	0.0 seconds or longer and shorter than 0.2 seconds	0.2 seconds or longer and shorter than 0.5 seconds	0.5 seconds or longer and shorter than 1.0 seconds	1.0 seconds or longer and shorter than 2.0 seconds	2.0 seconds or longer and shorter than 5.0 seconds	5.0 seconds or longer and shorter than … seconds	...	600 seconds or longer (warm-up)
232	Correction coefficient	1.00	1.10	1.20	1.23	1.30	1.50	...	2.10

FIG. 7

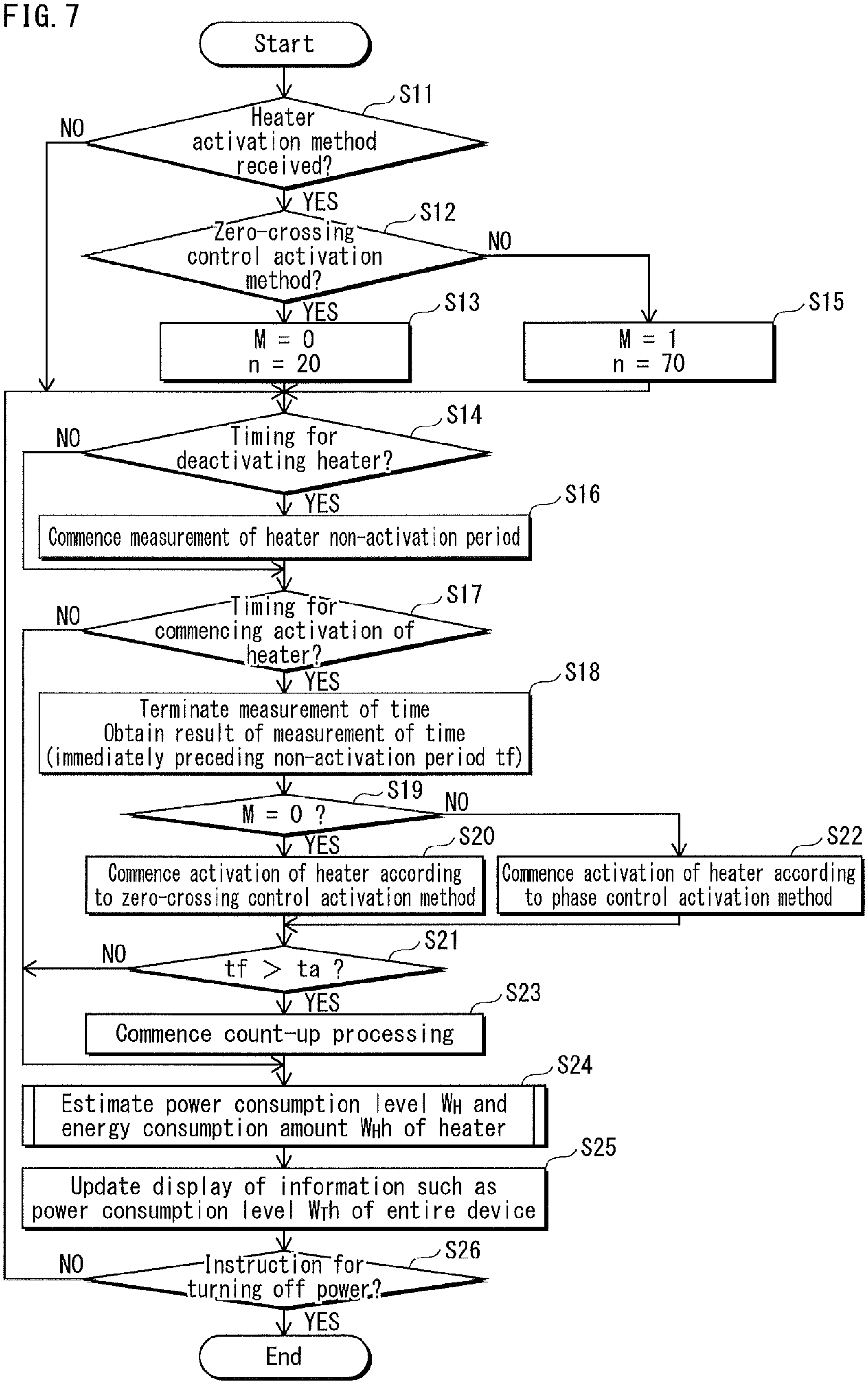

Start
S11
Heater activation method received?
NO
YES
S12
Zero-crossing control activation method?
NO
YES
S13
M = 0
n = 20
S15
M = 1
n = 70
S14
Timing for deactivating heater?
NO
YES
S16
Commence measurement of heater non-activation period
S17
Timing for commencing activation of heater?
NO
YES
S18
Terminate measurement of time
Obtain result of measurement of time
(immediately preceding non-activation period tf)
S19
M = 0 ?
NO
YES
S20
Commence activation of heater according to zero-crossing control activation method
S22
Commence activation of heater according to phase control activation method
S21
tf > ta ?
NO
YES
S23
Commence count-up processing
S24
Estimate power consumption level WH and energy consumption amount WHh of heater
S25
Update display of information such as power consumption level WTh of entire device
S26
Instruction for turning off power?
NO
YES
End

FIG. 8

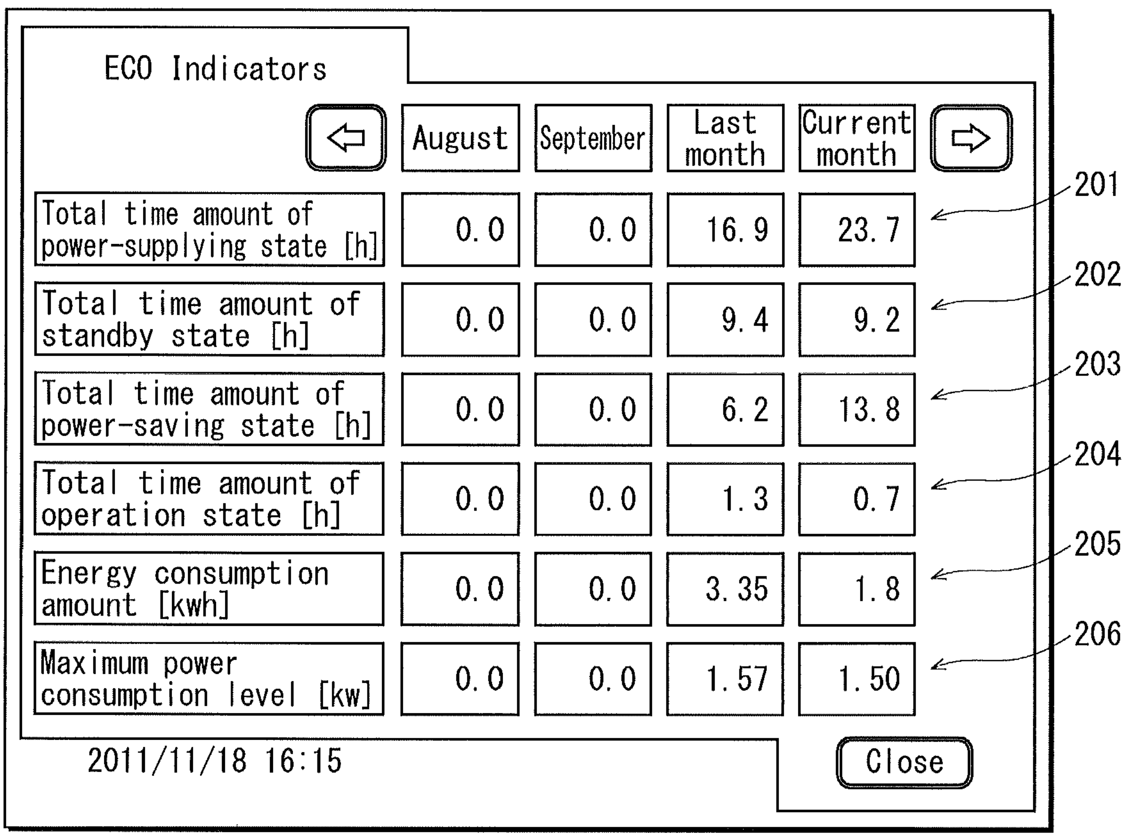

ECO Indicators
August
September
Last month
Current month
Total time amount of power-supplying state [h]
0.0
0.0
16.9
23.7
201
Total time amount of standby state [h]
0.0
0.0
9.4
9.2
202
Total time amount of power-saving state [h]
0.0
0.0
6.2
13.8
203
Total time amount of operation state [h]
0.0
0.0
1.3
0.7
204
Energy consumption amount [kwh]
0.0
0.0
3.35
1.8
205
Maximum power consumption level [kw]
0.0
0.0
1.57
1.50
206
2011/11/18 16:15
Close

FIG. 9

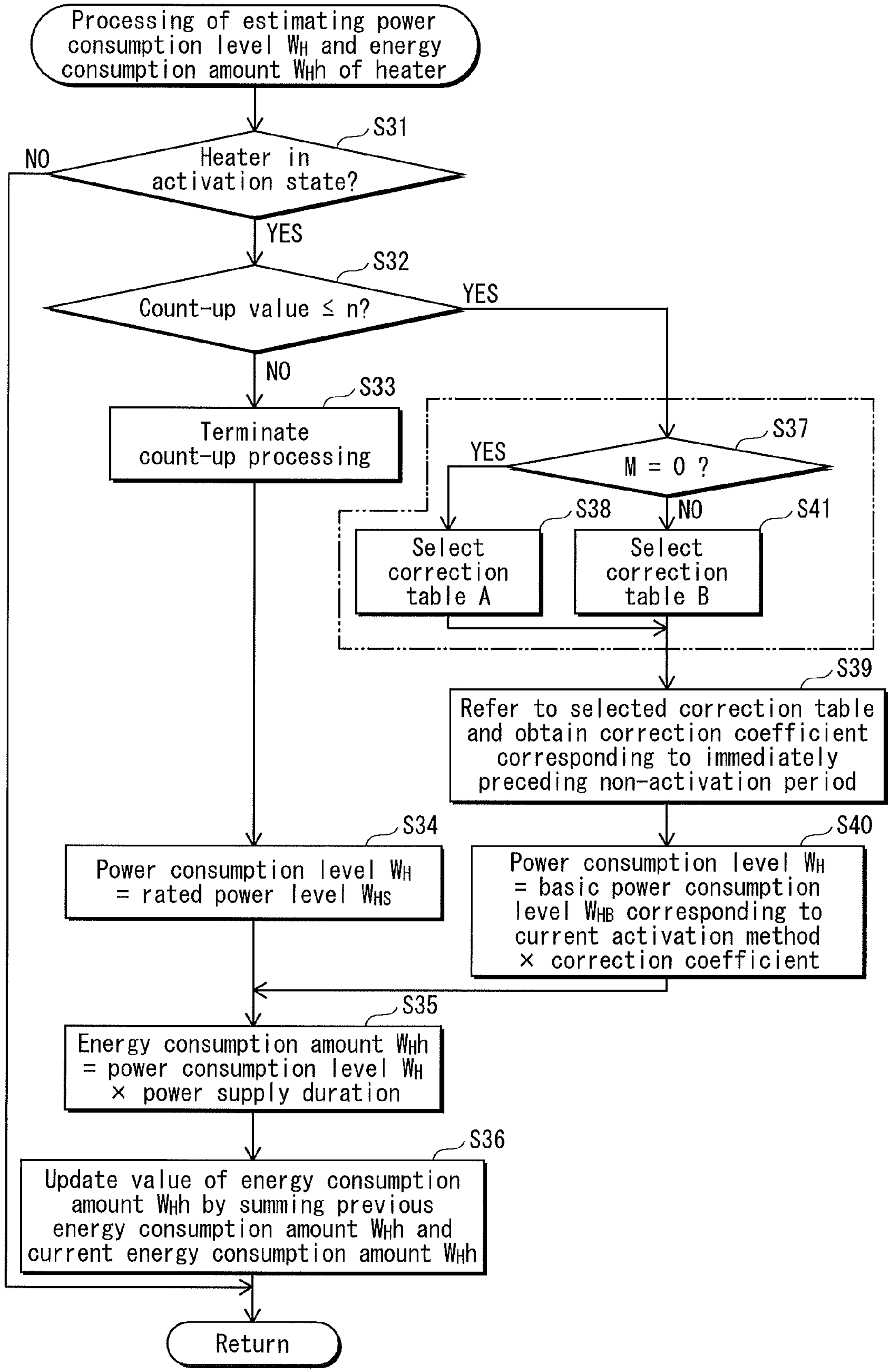

Processing of estimating power consumption level WH and energy consumption amount WHh of heater
S31
Heater in activation state?
NO
YES
S32
Count-up value ≤ n?
YES
NO
S33
Terminate count-up processing
S37
M = 0 ?
YES
NO
S38
Select correction table A
S41
Select correction table B
S39
Refer to selected correction table and obtain correction coefficient corresponding to immediately preceding non-activation period
S34
Power consumption level WH = rated power level WHS
S40
Power consumption level WH = basic power consumption level WHB corresponding to current activation method × correction coefficient
S35
Energy consumption amount WHh = power consumption level WH × power supply duration
S36
Update value of energy consumption amount WHh by summing previous energy consumption amount WHh and current energy consumption amount WHh
Return

FIG. 10A

Correction table C
(zero-crossing control activation method)

Immediately preceding non-activation period	0.0 seconds or longer and shorter than 0.2 seconds	0.2 seconds or longer and shorter than 0.5 seconds	0.5 seconds or longer and shorter than 1.0 seconds	1.0 seconds or longer and shorter than 2.0 seconds	2.0 seconds or longer and shorter than 5.0 seconds	5.0 seconds or longer and shorter than … seconds	...	600 seconds or longer (warm-up)
Correction coefficient	1.05	1.25	1.40	1.55	1.85	2.55	...	4.20

FIG. 10B

Correction table D
(phase control activation method)

Immediately preceding non-activation period	0.0 seconds or longer and shorter than 0.2 seconds	0.2 seconds or longer and shorter than 0.5 seconds	0.5 seconds or longer and shorter than 1.0 seconds	1.0 seconds or longer and shorter than 2.0 seconds	2.0 seconds or longer and shorter than 5.0 seconds	5.0 seconds or longer and shorter than … seconds	...	600 seconds or longer (warm-up)
Correction coefficient	1.03	1.13	1.23	1.26	1.33	1.53	...	2.10

FIG. 11

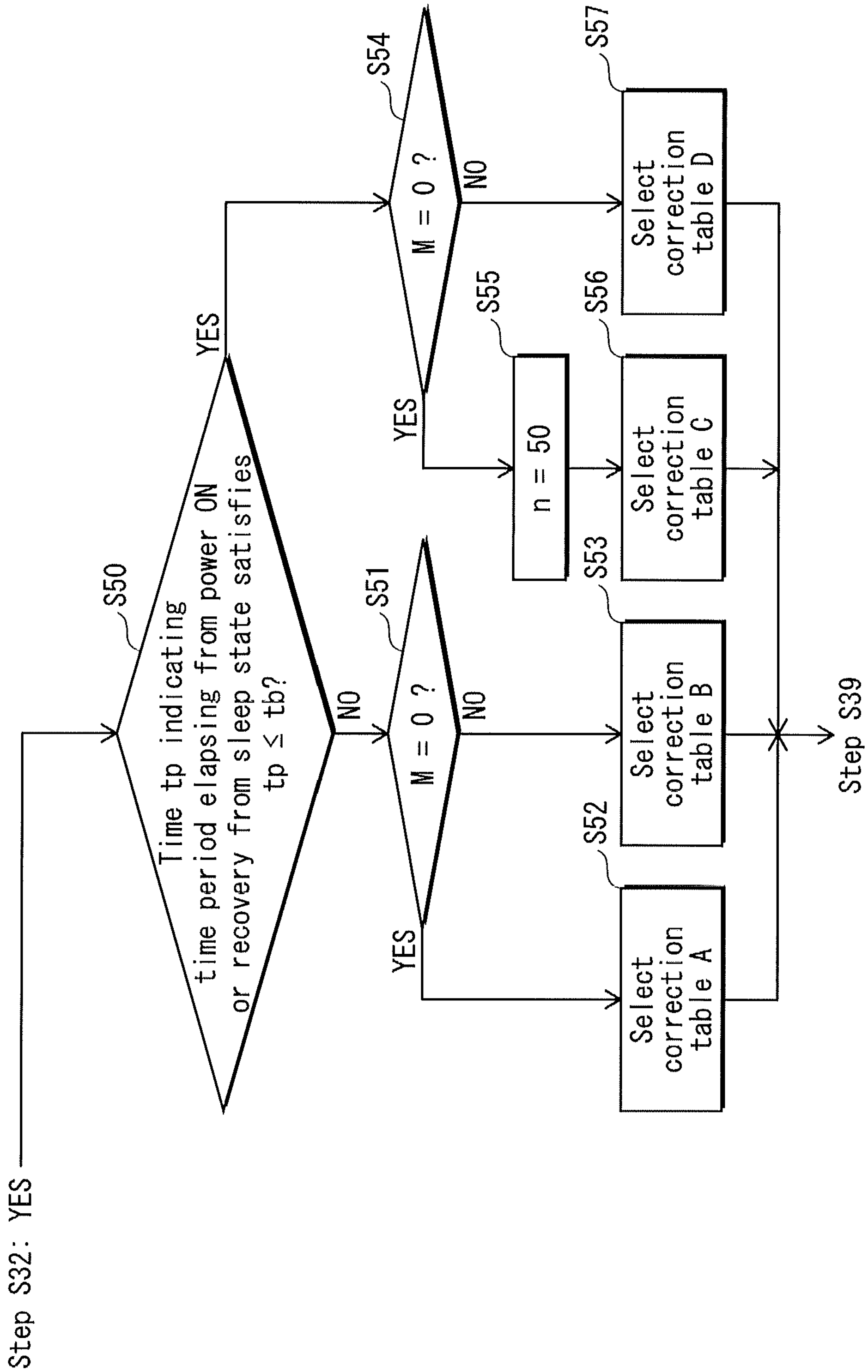

Step S32: YES
S50
Time tp indicating time period elapsing from power ON or recovery from sleep state satisfies tp ≤ tb?
YES
NO
S51
M = 0 ?
YES
NO
S52
Select correction table A
S53
Select correction table B
S54
M = 0 ?
YES
NO
S55
n = 50
S56
Select correction table C
S57
Select correction table D
Step S39

IMAGE FORMING APPARATUS CAPABLE OF ACCURATELY ESTIMATING POWER CONSUMPTION LEVEL

This application is based on an application No. 2012-148653 filed in Japan, the contents of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to an image forming apparatus having a fixing unit, and in particular, to estimation of a power consumption level in the fixing unit.

(2) Description of the Related Art

An electrophotographic image forming apparatus such as a printer commonly has a fixing unit that includes a pressurizing roller and a fixing roller including a heater such as a halogen lamp. Such a fixing unit, when a recording sheet having an unfixed toner image formed thereon passes through a fixing nip formed between the pressurizing roller and the fixing roller by the pressurizing roller pressing against the fixing roller, heat-fixes the toner image onto the recording sheet.

Such an image forming apparatus is no exception in the demand for energy conservation growing stronger year by year. In particular, there is a demand for a structure implementable in an image forming apparatus that enables a user to accurately keep track of power consumed by the image forming apparatus.

Commonly, an image forming apparatus executes predetermined processing such as a print job while switching on and off components such as a heater included in a fixing unit and one or more motors for driving one or more photosensitive drums, rollers, etc. Here, it should be noted that components such as a motor and a heater may operate at a power consumption level (i.e., a power level) indicating greater power than a rated power level thereof, and therefore may consume more energy than regularly consumed, particularly when an inrush of a large, instantaneous current takes place upon commencement of power supply thereto (i.e., when an inrush current occurs).

When it is desired to accurately estimate an overall power consumption level of the entire image forming apparatus, such an increase in power consumption level brought about by the inrush current cannot be ignored when taking place in the heater in the fixing unit. This is since power consumed by the heater corresponds to a great proportion of power consumed by the entire image forming apparatus.

As such, it may be considered to provide the image forming apparatus with a structure where a wattmeter or the like is provided for actually measuring the increase in power consumption level brought about by the inrush current. However, the provision of such a measurement equipment to the image forming apparatus results in increased device cost.

In view of such problems, Japanese Patent Application Publication No. 2010-152210 discloses calculating the power consumption level of the heater by assuming that a certain amount of power is additionally consumed by the heater each time the heater is activated due to inflow of the inrush current to the heater and by adding a value indicating the additional power consumption to the rated power level of the heater.

By performing calculation in such a manner, the power consumption level of the heater can be estimated with higher accuracy compared to when the effect of the inrush current is not taken into consideration.

However, according to results of confirmation performed by the present inventors, the level of the inrush current flowing into the heater upon commencement of power supply differed depending upon a duration of an interval from deactivation of the heater to the activation of the heater. In fact, the present inventors determined through such confirmation that the method described in Japanese Patent Application Publication No. 2010-152210, which involves adding, each time the heater is activated, a uniform value indicating the increase in power consumption level of the heater brought about by the inrush current to the rated power level of the heater, does not enhance the accuracy of the estimation of the power consumption level of the heater by much.

SUMMARY OF THE INVENTION

In view of the problems described above, the present invention provides an image forming apparatus that enables accurate estimation of the power consumption level of the heater included in the fixing unit without having to actually measure the increase in power consumption level of the heater brought about by the inrush current.

One aspect of the present invention is an image forming apparatus having a fixing unit that includes a pressurizing member, a heating rotational body, and a heater, wherein the fixing unit adjusts a temperature of the heating rotational body by switching a state of the heater between a heating state where the heater receives power supply and a non-heating state where the heater does not receive power supply, and the fixing unit, when a recording sheet having an unfixed toner image formed thereon passes through a fixing nip formed between the heating rotational body and the pressurizing member by the pressurizing member pressing against the heating rotational body, heat-fixes the toner image onto the recording sheet, the image forming apparatus comprising: a storage unit that stores a basic power consumption level of the heater determined in advance in a situation where the heater is in the heating state and where inflow of inrush current to the heater is not occurring; an estimation unit that calculates an estimated power consumption level of the heater by (i) estimating, according to a duration of a non-heating state immediately preceding the heating state, an increase in the power consumption level of the heater, with respect to the basic power consumption level of the heater, brought about by inflow of inrush current to the heater occurring when the heater is switched from the immediately preceding non-heating state to the heating state, and (ii) adding the increase in the power consumption level of the heater to the basic power consumption level of the heater; and an output unit that outputs the estimated power consumption level of the heater.

BRIEF DESCRIPTION OF THE DRAWINGS

These and the other objects, advantages and features of the invention will become apparent from the following description thereof taken in conjunction with the accompanying drawings which illustrate a specific embodiment of the invention.

In the drawings:

FIG. **1** is a schematic cross-sectional view illustrating a structure of an image forming apparatus pertaining to embodiment 1 of the present invention;

FIG. **2** is a block diagram illustrating a. control unit of the image forming apparatus pertaining to embodiment 1 and constituent elements of the image forming apparatus pertaining to embodiment 1 that are controlled by the control unit;

FIG. **3** is a timing chart illustrating a relationship, in the image forming apparatus pertaining to embodiment 1, between an input voltage of a triac of the image forming apparatus, an output voltage of the triac, a zero-crossing signal, and a heater activation signal when a zero-crossing control activation method is employed;

FIG. **4** is a timing chart illustrating a relationship, in the image forming apparatus pertaining to embodiment 1, between the input voltage of the triac, the output voltage of the triac, the zero-crossing signal, and the heater activation signal when a phase control activation method is employed;

FIG. **5** illustrates a relationship between durations of an immediately preceding non-activation period and correction coefficients;

FIG. **6**A illustrates a correction table A for correcting a power consumption level of the heater when the zero-crossing control activation method is selected, and FIG. **6**B illustrates a correction table B for correcting the power consumption level of the heater when the phase control activation method is selected;

FIG. **7** is a flowchart illustrating execution procedures involved in heater power estimation executed by the control unit of the image forming apparatus;

FIG. **8** illustrates an example of display performed by a display unit provided to the image forming apparatus;

FIG. **9** is a flowchart illustrating contents of a subroutine corresponding to Step S**24** in FIG. **7**;

FIG. **10**A illustrates a correction table C for correcting the power consumption level of the beater upon activation of an image forming apparatus pertaining to embodiment 2 of the present invention or recovery from a long-period sleep state of the image forming apparatus pertaining to embodiment 2 when the zero-crossing control activation method is employed, and FIG. **10**B illustrates a correction table B for correcting the power consumption level of the heater upon activation of the image forming apparatus pertaining to embodiment 2 or recovery from the long-period sleep state of the image forming apparatus pertaining to embodiment 2 when the phase control activation method is employed; and

FIG. **11** is a flowchart illustrating a new subroutine executed in place of steps surrounded by chained double-dashed lines in FIG. **9** by the image forming apparatus pertaining to embodiment 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

(1) Embodiment 1

In the following, description is provided on an image forming apparatus pertaining to embodiment 1 of the present invention with reference to the accompanying drawings.

(1-1) Structure of Image Forming Apparatus

FIG. **1** is a schematic cross-sectional view for describing a structure of a printer that is one example of the image forming apparatus pertaining to embodiment 1 of the present invention.

A printer **1** includes: an image forming unit **10**; a paper feeding unit **20**; a fixing unit **30**; a power source unit **5**; a control unit **6**; and an operation panel **7**.

The paper feeding unit **20** includes: a storage tray **21**; a feed roller **22**; a separation roller pair **23**; a timing roller pair **24**; and a discharge roller **31**.

The storage tray **21** is a box for accommodating recording sheets.

The feed roller **22** contacts the topmost recording sheet in the storage tray **21** and feeds the recording sheet onto a path along which recording sheets are transported in the printer **1** (hereinafter referred to as a sheet transport path).

The separation roller pair **23** is constituted of a driving roller and a driven roller that is driven by the driving roller. The driving roller and the driven roller form a separation nip by contacting one another. Further, a torque limiter is attached to the driven roller, whereby a force in a direction opposite the direction in which the recording sheet is transported along the sheet transport path is exerted on the recording sheet.

The torque limiter prevents double-fed recording sheets from being transported further along the transport path, by separating the double-fed recording sheets from one another. Here, the term "double-fed recording sheets" is used to refer to a state where another recording sheet is carried along by the recording sheet being transported along the sheet transport path.

The timing roller pair **24** sends out the recording sheet further downstream along the sheet transport path at a timing instructed by the control unit **6**.

The image forming unit **10**, as illustrated in FIG. **1**, includes imaging units **11**Y, **11**M, **11**C, and **11**K respectively corresponding to the colors yellow (Y), magenta (M), cyan (C), and black (K). In addition, the image forming unit **10** includes: an intermediate transfer belt **13**; a second transfer roller **15**; and a plurality of first transfer rollers **14** each facing a photosensitive drum **12** built into a corresponding one of the imaging units **11**Y, **11**M, **11**C, and **11**K.

As illustrated in FIG. **1**, the imaging units **11**Y, **11**M, **11**C, and **11**K are disposed in the stated order along the intermediate transfer belt **13** with a predetermined interval between one another.

For instance, the imaging unit **11**K, in addition to including a corresponding photosensitive drum **12**, includes: a charger **16**; an exposure unit **17**; a developer **18**; and a cleaner **19**. In the imaging unit **11**K, the charger **16**, the exposure unit **17**, the developer **18**, and the cleaner **19** are disposed along a circumference of the corresponding photosensitive drum **12**.

Note that since the structure of each of the imaging units **11**Y, **11**M, and **11**C is similar to that of the imaging unit **11**K, description thereon is omitted herein.

The exposure unit **17**, in each of the imaging units **11**Y, **11**M, **11**C, and **11**K, includes a lens and light-emitting elements such as laser diode elements. The exposure unit **17** obtains a drive signal from the control unit **6**, emits a laser beam for exposure-scanning the corresponding photosensitive drum **12**, and thereby exposure-scans the corresponding photosensitive drum **12** in a main scanning direction. Note that the drive signal obtained by the exposure unit **17** is generated by the control unit **6** according to image data acquired from an external source via a LAN, etc.

The photosensitive drum **12**, in each of the imaging units **11**Y, **11**M, **11**C, and **11**K, is driven to rotate by an undepicted drive source. Further, before exposure-scanning by the exposure unit **17**, residual toner on the surface of the photosensitive drum **12** is removed by the cleaner **19**, and charge remaining on the surface of the photosensitive drum **12** is erased by an undepicted erase lamp. Following the removal of residual toner and charge, the surface of the photosensitive drum **12** is uniformly charged by the charger **16**. When the surface of the photosensitive drum **12**, now having uniform charge along an entirety thereof, is exposure-scanned by the laser beam as described above, an electrostatic latent image is formed thereon.

In each of the imaging units **11**Y, **11**M, **11**C, and **11**K, the electrostatic latent image formed on the surface of the corresponding photosensitive drum **12** undergoes developing by the developer **18** of the corresponding color. As such, a toner image of a corresponding color among the colors Y, M, C, and K is formed on the surface of the respective photosensitive drums **12**.

The creation of the toner image of the corresponding color by each of the imaging units **11**Y, **11**M, **11**C, and **11**K is performed at a different timing such that the toner images formed by the respective imaging units **11**Y, **11**M, **11**C, and **11**K are transferred so as to be overlaid one on top of another at the same position of the intermediate transfer belt **13**. A toner image of a given color formed on the photosensitive drum **12** included in the corresponding one of the imaging units **11**Y, **11**M, **11**C, and **11**K is transferred onto the intermediate transfer belt **13** by electrostatic force applied by the corresponding first transfer roller **14**. By multi-transfer of toner images onto the immediate transfer belt **13** being performed as described above, a full-color toner image is formed on the intermediate transfer belt **13**.

The toner images overlaid one on top of another on the intermediate transfer belt **13** are then carried to a second transfer position by the rotation of the intermediate transfer belt **13**.

In the meantime, the recording sheet is transported towards the second transfer position from the paper feeder **20** via the timing roller pair **24**. Here, note that the timing at which the recording sheet is supplied to the second transfer position is adjusted so as to coincide with the timing at which the toner images on the intermediate transfer belt **13** arrive at the second transfer position. When arriving at the second transfer position, the toner images on the intermediate transfer belt **13** are transferred onto the recording sheet (i.e., a second transfer is carried out) by electrostatic force resulting from voltage applied to the second transfer roller **15**. Following the second transfer, the recording sheet having the toner images transferred thereon is transported to the fixing unit **30**.

The fixing unit **30** includes: a fixing roller **131** having a built-in heater **131***a;* and a pressurizing roller **132**. The fixing roller **131** and the pressurizing roller **132** are disposed so as to be in parallel alignment with respect to each other and so as to press against each another. Due to the fixing roller **131** and the pressurizing roller **132** being disposed in such a manner, a fixing nip is formed between the fixing roller **131** and the pressurizing roller **132**.

Here, the pressurizing roller **132** is driven, for instance, by an undepicted drive source, and the fixing roller **131** is caused to passively rotate when the pressurizing roller **132** rotates.

The heater **131***a* is a halogen lamp and heats the fixing roller **131** from inside. The fixing roller **131** is heated mainly due to the radiant heat generated and output by the heater **131***a*.

In addition, the fixing unit **30** is also provided with a temperature sensor **133** that detects a surface temperature of the fixing roller **131**.

When the recording sheet passes through the fixing nip, the toner images having been transferred onto the surface of the recording sheet are heat-fixed onto the recording sheet by application of heat and pressure. Following the heat-fixing, the recording sheet is discharged onto the discharge tray **32** via the discharge roller pair **31**.

The power source unit **5** is, for instance, connected to a commercial AC power source supplying AC voltage of 100 V, 50 Hz and supplies electric power (hereinafter referred to simply as "power") to the heater **131***a*, an undepicted drive source, etc.

The operation panel **7** includes a numeric keypad, a touch panel, etc., receives instructions from an operator of the printer **1**, and displays information for the operator to see.

The control unit **6** has overall control over the image forming unit **10**, the paper feeder **20**, the fixing unit **30**, etc. The control performed by the control unit **6** includes driving an undepicted drive source at a predetermined timing

The control unit **6** also performs conventional temperature adjustment control of the heater **131***a* according to detection results of the temperature sensor **133**. More specifically, the control unit **6** activates the heater **131***a* when the temperature detected by the temperature sensor **133** is equal to or lower than a predetermined target temperature and deactivates the heater **131***a* when the detected temperature exceeds the predetermined target temperature.

In addition, the control unit **6** included in the printer **1** pertaining to the present embodiment estimates a power consumption level of the entire printer **1** and causes the operation panel **7** to display information such as a maximum power consumption level of the printer **1** for each month. The control performed by the control unit **6** is described in detail later in the present disclosure.

(1-2) Configuration of Power Source Unit and Control Unit

FIG. **2** illustrates a configuration of the power source unit **5** and the control unit **6** in the printer **1**, and also illustrates a relationship between the control unit **6** and the main constituent elements that are controlled by the control unit **6**.

The power source unit **5** includes: a zero-crossing detection circuit **151**; an AC/DC converter **152**; a DC/DC converter **153**; and a triac **154**.

The zero-crossing detection circuit **151**, when detecting that voltage output from a commercial AC power source **4** equals zero, outputs a signal (hereinafter referred to as a zero-crossing signal) indicating that the voltage output from the commercial AC power source **4** has equaled zero to the control unit **6**.

The AC/DC converter **152** converts AC voltage into DC voltage.

The DC/DC converter **153** coverts DC voltage output from the AC/DC converter **152** to DC voltage having reduced voltage and supplies the DC voltage thus converted to the control unit **6**.

The triac **154** controls the amount of power supply to the heater **131***a* by opening or closing a power supply path in accordance with an activation signal output by the control unit **6**. More specifically, the triac **154**, when not conducting, closes the power supply path, while the triac **154**, when conducting, functions as a short circuit and completes the power supply path.

Here, note that although undepicted in FIG. **2**, the power source unit **5** has a plurality of additional triacs similar to the traic **154**, and thereby supplies power to drive sources (undepicted) for the photosensitive drums **12**, the rollers, etc., included in the printer **1**.

The control unit **6** includes, as main constituent elements thereof, a central processing unit (CPU) **161**, a timer **162**, a read only memory (ROM) **163**, a random access memory (RAM) **164**, an electronically erasable and programmable read only memory (EEPROM) **165**, and a communication interface (I/F) unit **166**,

The RAM **164** is a volatile memory that functions as a work area during execution of one or more programs by the CPU **161**.

The timer **162** measures time according to instructions from the CPU **161**.

The ROM **163** stores therein control programs that execute control related to the execution of printing and heater power estimation as described in detail later in the present disclosure.

The EEPROM **165** is a non-volatile memory that functions as an area to which the CPU **161** stores data.

The communication I/F unit **166** is an interface, such as a LAN card and a LAN board, for connecting to a LAN.

The CPU **161** executes conventional operations such as a warm-up operation and a print operation by executing the control programs stored in the ROM **163**. Further, in addition to executing such conventional operations, the CPU **161** also performs, in accordance with a signal output from the temperature sensor **133** of the fixing unit **30**, a conventional temperature adjustment control of maintaining the surface temperature of the fixing roller **131** at a predetermined target temperature by outputting, to the triac **154**, an activation signal for activating the heater **131***a* provided in the fixing roller **131**.

When causing the heater **131***a* to activate, the CPU **161** outputs a signal (hereinafter referred to as a heater activation signal) instructing the triac **154** to complete the power supply path by functioning as a short circuit. While the CPU **161** is outputting the heater activation signal, voltage from the commercial AC power source **4** is applied to the heater **131***a*.

Here, note that in the printer **1**, two different activation methods are employed as activation methods for activating the heater **131***a*, namely a zero-crossing control activation method and a phase control activation method, and the CPU **161** activates the heater **131***a* according to one of the two activation methods having been selected by a user via the operation panel **7**. The two activation methods as described above are employed in order to reduce the level of the inrush current occurring immediately following the activation of the heater **131***a* and to prevent counter electromotive force occurring upon deactivation of the heater **131***a*.

In further addition to the above, the CPU **161** pertaining to the present embodiment executes processing of estimating a power consumption level of the heater **131***a* and an energy consumption amount (i.e., a total amount of energy consumed within a given time period) of the heater **131***a* (hereinafter referred to as "heater power estimation"), and further, executes processing of estimating a power consumption level of the entire printer **1** and an energy consumption amount of the entire printer **1**. Such processing is described in detail later in the present disclosure.

In the following, description is provided on the activation methods of the heater **131***a*.

(1-3) Activation Methods of Heater

FIG. **3** is a timing chart that explains the zero-crossing control activation method. More specifically, FIG. **3** illustrates a relationship between a voltage V_I input to the triac **154**, a voltage V_O output from the triac **154**, a zero-crossing signal S_1 output from the zero-crossing detection circuit **151**, and a heater activation signal S_2.

When the zero-crossing control activation method is selected, the CPU **161**, when determining that the heater **131***a* is to be activated in the process of the above-described temperature adjustment control, commences output of the heater activation signal S_2 to the triac **154** at a time point at which the zero-crossing signal S_1 is subsequently output from the zero-crossing detection circuit **151** (e.g., time point t**1**). On the other hand, when determining that the heater **131***a* is to be deactivated, the CPU **161** terminates the output of the heater activation signal S_2 to the triac **154** at a time point (e.g., time point t**4**) at which the zero-crossing signal S_1 is subsequently output from the zero-crossing detection circuit **151**.

According to the zero-crossing control activation method, the voltage applied to the heater **131***a* rises (falls) starting from 0 V in accordance with an AC voltage waveform. As such, the current flowing into the heater **131***a* rises (falls) at a moderate rate, whereby the inflow of inrush current to the heater **131***a* is suppressed.

In addition, according to the zero-crossing control activation method, the power supply to the heater **131***a* is terminated when the voltage applied to the heater **131***a* is 0 V. As such, the generation of counter electromotive force is prevented.

FIG. **4** is a timing chart that explains the phase control activation method. More specifically, FIG. **4** illustrates a relationship between the voltage V_1 input to the triac **154**, the voltage V_O output from the triac **154**, the zero-crossing signal S_1 output from the zero-crossing detection circuit **151**, and a heater activation signal S_3.

When the phase control activation method is selected, the CPU **161**, when determining that the heater **131***a* is to be activated in the process of the temperature adjustment control, commences output of the heater activation signal S_3 to the triac **154** at a time point at which the zero-crossing signal S_1 is subsequently output from the zero-crossing detection circuit **151** (e.g., time point t**20**). Further, for a period of for instance 70 ms (e.g., t**20** to t**22**), the CPU **161** outputs the heater activation signal S_3 to the triac **154** such that a conduction phase angle (time corresponding to "ON" state) during which the triac **154** conducts increases in a step-like manner until a duty ratio reaches 100% from 0%.

When determining that the heater **131***a* is to be deactivated, similar as when the zero-crossing control activation method is selected, the CPU **161** terminates the output of the heater activation signal S_3 to the triac **154** at a time point at which the zero-crossing signal S_1 is subsequently output from the zero-crossing detection circuit **151** (e.g., time point t**23**).

As such, when the phase control activation method is employed, the power supply to the heater **131***a* is terminated when the voltage applied to the heater **131***a* is 0 V, similar as when the zero-crossing control activation method is employed. As such, the generation of counter electromotive force is prevented.

Here, note that when the phase control activation method is employed, the operations involved during a period from the commencement of the output of the heater activation signal S_3 to the termination of the output of the heater activation signal S_3 (e.g., in FIG. **4**, the period between time point t**20** and time point t**23** and the period between time point t**24** and time point t**25**), which includes the transition from intermittent output of the heater activation signal S_3 to continuous output of the heater activation signal S_3, are considered as constituting a sequence of heating operations for activating the heater **131***a*. Therefore, the state of the heater **131***a* during this period (hereinafter referred to as a "heating period") is hereinafter referred to as a "heating state". Note that the heating state includes the state of the heater **131***a* when the output of the heater activation signal S_3 to the heater **131***a* is intermittently suspended.

When the zero-crossing control activation method is employed, the heater **131***a* is considered to be in the heating state while the heater activation signal S_2 is being output from the triac **154** (e.g., in FIG. **3**, the period between time point t**1** and time point t**4** and the period between time point t**5** and time point t**6**).

Further, in both activation methods, the state of the heater **131***a* when not in the heating state is hereinafter referred to as a "non-heating" state.

When the phase control activation method is employed, the conduction phase angle of the triac **154** gradually increases in units of half-waves upon commencement of the activation of the heater **131***a*. Therefore, the amount by which the current flowing into the heater **131***a* changes is relatively small, and also, the current flowing into the heater **131***a* changes at a relatively short cycle. As such, the occurrence of the inrush current can be suppressed to a greater extent compared to when the zero-crossing control activation method is employed, whereby the generation of flickers can be suppressed.

Note that here, the term "flickers" refers to undesirable phenomena, such as flickering of an illumination apparatus connected to the commercial AC power source **4**, brought about by a rapid change in AC power voltage supplied from the commercial AC power source **4**. Such a rapid change in the AC power voltage is brought about due to a change in a load current of the printer **1**, and impedance characteristics of the commercial AC power source **4**, a power distribution network of the installation site of the printer **1**, etc.

In addition, when the phase control activation method is employed, the power supply to the heater **131***a* can be controlled in units of half-waves. Hence, the heater **131***a* responds more quickly to the temperature adjustment control performed compared to when the zero-crossing control activation method is employed. As such, the phase control activation method has an advantage that temperature ripple of the heater **131***a* can be reduced.

The phase control activation method, at the same time as having advantages such as described above, also has certain disadvantages. That is, as described above, the heater **131***a* is activated at an arbitrary phase angle within a half-wave of the AC voltage according to the phase control activation method. This brings about an instantaneous change in the current supplied to the heater **131***a*, which results in the generation of harmonic current distortion and/or switching noises (abnormal noises).

The circumstances being as such, the user or the serviceman of the printer **1** selects, via the operation panel **7**, one of the two activation methods described above that he/she assumes to be more suitable for the usage environment of the printer **1**.

(1-4) Estimation of Power Consumption Level and Energy Consumption Amount of Printer

The CPU **161** estimates a maximum power consumption level of the entire printer **1** and an energy consumption amount of the entire printer **1** for each month and displays the results of the estimation on the operation panel **7**.

In order to be able to perform the above-described estimation of the maximum power consumption level and the energy consumption amount of the entire printer **1**, the CPU **161** needs to be capable of keeping track of the power consumption level of each device included in the printer **1**.

Basically, the CPU **161** assumes that a given device consumes power corresponding to the rated power level of the device when power is supplied thereto.

Further, the CPU **161** calculates an energy consumption amount of the given device by causing the timer **162** to measure the amount of time during which power has been supplied to the device within a given period, and by multiplying the amount of time so measured by a value indicating the rated power level of the device, which is stored in the ROM **163**. Further, the CPU **161** adds the energy consumption amount for the given period so calculated to a total energy consumption amount stored in the EEPROM **165**.

The total energy consumption amount of the given device for each month is stored in a table stored in the EEPROM **165**, whereby a record can be kept of the energy consumption amount of the device in units of months.

In the meantime, here, it should be noted that either one of the two heater activation methods described above can reduce the level of the inrush current occurring but cannot completely suppress the occurrence of the inrush current.

In addition, it should also be noted that, since activation and deactivation of the heater **131***a* is repeated frequently, the increase in power consumed by the heater **131***a* due to the occurrence of the inrush current (hereinafter referred to as an "increased power consumption" of the heater **131***a*) is greater than observed in the other devices included in the printer **1**, and hence, needs to be taken into consideration when estimating the power consumption level of the heater **131***a*. In other words, if the estimation of the power consumption level of the heater **131***a* were to be performed in the manner described above with respect to the other devices included in the printer **1**, the estimated power consumption level of the heater **131***a* would differ from the actual power consumption level of the heater **131***a*.

In view of this, the printer **1** pertaining to the present embodiment performs processing of estimating the power consumption level of the heater **131***a* by first calculating the above-described increased power consumption of the heater **131***a*, and by then adding the increased power consumption so estimated to the rated power level of the heater **131***a*. This processing is hereinafter referred to as "heater power estimation".

(1-5) Inrush Current and Power Consumption Level

The present inventors have conducted an experiment as described in the following for each of the two activation methods. In the experiments, the present inventors used a wattmeter to measure an average power consumption level of the heater **131***a* within each of two periods, namely an initial activation period and a stable activation period. The initial activation period refers to a period from the commencement of the activation of the heater **131***a* to a point where the inrush current occurring upon the activation of the heater **131***a* substantially disappears. The stable activation period refers to a period following the initial activation period, during which the heater **131***a* is kept in activation state.

Here, note that the power consumption level of the heater **131***a* can be calculated by first integrating a momentary power value, which is a product of a momentary voltage value and a momentary current value, within a predetermined tune period (commonly, a period corresponding to one cycle of applied voltage) to calculate the energy consumption amount of the heater **131***a* during the predetermined time period, and by dividing the energy consumption amount by the predetermined time period.

In a strict sense, the duration from the commencement of the activation of the heater **131***a* to the point where the inrush current substantially disappears, or that is, the duration of the initial activation period changes according to activation conditions of the heater **131***a* such as a duration of an interval from deactivation of the heater **131***a* to the activation of the heater **131***a*.

However, the printer **1**, when actually implemented, does not include any equipment such as an ammeter and a wattmeter capable of detecting the occurrence of the inrush current. As such, the printer **1** is not capable of detecting the actual duration of the initial activation period.

In view of this, the present inventors have conducted the above-described experiment for each of the two activation methods of the heater **131***a* in advance to measure the chronological change in current flowing into the heater **131***a* for different activation conditions of the heater **131***a*, and thereby determined the amount of time that was required for the inrush current to substantially disappear in each of the activation conditions. And further, for each of the two activation methods, the present inventors regarded the greatest one among the different amounts of time so measured as the initial activation period of the heater **131***a*, which is applied in common to all activation conditions of the heater **131***a* when estimating the power consumption level of the heater **131***a*.

Note that the term "initial activation period" appearing in the following description refers to an initial activation period having been set in such a manner.

According to the above-described experiments, it was confirmed that the heater **131***a* consumes power equivalent to the rated power level thereof during the stable activation period.

In addition, it was also found that the increase in the amount of power consumed by the heater **131***a* brought about by the occurrence of the inrush current upon commencement of the activation of the heater **131***a*, or that is, the increased power consumption of the heater **131***a* increases as a duration increases of a period (hereinafter referred to as an "immediately preceding non-activation period") during which the heater **131***a* is in a non-activation state immediately preceding the commencement of power supply to the heater **131***a*.

Based on this finding, the present inventors made an assumption that the power consumption level of the heater **131***a* can be estimated accurately by determining the relationship between durations of the immediately preceding non-activation period and values of the increased power consumption of the heater **131***a*, and conducted the above-described experiments.

Here, note that the above-described measurement was performed after print jobs were executed several times in repetition following the activation of the printer **1** and the completion of warm-up of the printer **1**, in order to approximate the experiment conditions to the normal usage conditions of the printer **1**.

FIG. **5** illustrates the relationship between durations of the immediately preceding non-activation period and correction coefficients.

Here, a correction coefficient is a value that is calculated by dividing an energy consumption amount of the heater **131***a* actually measured during the initial activation period, which starts at the commencement of the activation, by an energy consumption amount of the heater **131***a* (hereinafter referred to as a "basic energy consumption amount") during the initial activation period, determined in advance under the conditions described in the following where the inrush current does not substantially occur upon commencement of the activation of the heater **131***a* (hereinafter referred to as "stable activation conditions").

In specific, the present inventors found through the above-described experiments that the inrush current does not substantially occur when the heater **131***a* (i) is continuously activated for a relatively long period, (ii) is then deactivated while the temperature of the heater **131***a* is sufficiently high, and (iii) is then reactivated within 0.2 seconds from deactivation. The heater **131***a*, when activated according to the stable activation conditions, is activated in such a manner.

In addition, note that in the following description, a value indicating an average power consumption level of the heater **131***a* that is calculated by dividing the basic energy consumption amount by the initial activation period (time) is referred to as a "basic power consumption level" of the heater **131***a*.

When the zero-crossing control activation method is employed, the triac **154** conducts at a duty ratio of 100% from the commencement of the activation of the heater **131***a*. Due to this, when the heater **131***a* is activated according to the stable activation conditions, the basic power consumption level of the heater **131***a* is substantially equivalent to the rated power level of the heater **131***a*. Therefore, the basic energy consumption amount of the heater **131***a* during the initial activation period is substantially equivalent to an energy consumption amount that can be calculated by multiplying the rated power level of the heater **131***a* by the initial activation period (time).

In contrast to this, when the heater **131***a* is employed, the basic energy consumption amount of the heater **131***a*, when actually measured, indicates a smaller value than an energy consumption amount that can be calculated by multiplying the rated power level of the heater **131***a* by the initial activation period (time), and in addition, the basic power consumption level of the heater **131***a* indicates a smaller value than the rated power level of the heater **131***a*.

This is since, when the phase control activation method is employed, the conduction phase angle during which the triac **154** conducts (time corresponding to "ON" state) increases in a step-like manner until the duty ratio reaches 100% from 0%. As such, during the initial activation period, the power consumption level of the heater **131***a* also increases in a step-like manner.

In FIG. **5**, the curve indicated by reference sign **211** is a graph indicating the relationship between durations of the immediately preceding non-activation period and the correction coefficients in a case where the heater **131***a* is activated according to the zero-crossing control activation method, and, the curve indicated by reference sign **212** is a graph indicating the relationship between durations of the immediately preceding non-activation period and the correction coefficient in a case where the heater **131***a* is activated according to the phase control activation method.

As illustrated in FIG. **5**, the correction coefficients increase in value as the duration of the immediately preceding non-activation period increases, regardless of whether the zero-crossing control activation method or the phase control activation method is employed.

In addition, it should also be noted that this tendency is more prominent when the zero-crossing control activation method is employed compared to when the phase control activation method is employed.

This is since, as described above, the phase control activation method suppresses the occurrence of the inrush current to a greater degree compared to the zero-crossing control activation method.

The reason why such a relationship as described above exists between the duration of the immediately preceding non-activation period and the power consumption level of the heater **131***a* is assumed to be since the heater **131***a* has positive temperature coefficient (PTC) characteristics. That is, a longer immediately preceding non-activation period results in the temperature of the heater **131***a* falling to a lower temperature due to heat radiation, which further results in a decrease in the resistance of the heater **131***a*. When the resistance of the heater **131***a* decreases in such a manner, a great current flows through the heater **131***a* upon commencement of power supply thereto.

Here, note that in FIG. **5**, for each of the activation methods, illustration is provided of the correction coefficients when the immediately preceding non-activation period has a duration within a range of zero to five seconds. However, illustration is not provided in FIG. **5** of the correction coefficients for durations of the immediately preceding non-activation period of five seconds or greater.

The ROM **163** in the printer **1** pertaining to the present invention stores therein: the rated power level of the heater **131***a;* the rated power level of each device in the printer **1** other than the heater **131***a*; a correction table A; a correction table B; and the basic power consumption level of the heater

131*a* for each of the zero-crossing control activation method and the phase control activation method.

Each of the basic power consumption levels of the heater **131***a* stored in the ROM **163** is a value that has been obtained by conducting the above-described experiment for the corresponding activation method. Here, it should be noted that, as described above, the basic power consumption level of the heater **131***a* when the zero-crossing control activation method is employed is substantially equivalent to the rated power level of the heater **131***a*.

FIG. **6**A illustrates the specific contents of the correction table A, and FIG. **6**B illustrates the specific contents of the correction table B.

The correction table A is used for determining the correction coefficient to be used for correcting the power consumption level of the heater **131***a* when the zero-crossing control activation method is employed, and includes correction coefficients corresponding to durations of the immediately preceding non-activation period.

On the other hand, the correction table B is used for determining the correction coefficient to be used for correcting the power consumption level of the heater **131***a* when the phase control activation method is employed, and includes correction coefficients corresponding to durations of the immediately preceding non-activation period.

Note that the correction tables A and B have been prepared according to the relationship illustrated in FIG. **5** between the durations of the immediately preceding non-activation period and the correction coefficients.

As illustrated in the correction tables A and B, the correction coefficient is set to one when the immediately preceding non-activation period is shorter than 0.2 seconds, regardless of whether the zero-crossing control activation method or the phase control activation method is employed. This is since, the state of the heater **131***a* when the duration of the immediately preceding non-activation period is shorter than 0.2 seconds is almost the same as the state of the heater **131***a* in continuous activation.

That is, an assumption is made that the inflow of the inrush current to the heater **131***a* does not take place, and therefore, that the increase in power consumption level of the heater **131***a* does not take place for such a duration of the immediately preceding non-activation period.

In addition, when the duration of the immediately preceding non-activation period is 600 seconds or longer, or that is, when the heater **131***a* is activated after continuously being in the non-activation state for ten minutes or longer, the correction coefficient is set to a fixed value for each of the activation methods (namely, 4.20 for the zero-crossing control activation method and 2.10 for the phase control activation method).

The correction coefficient in such a case is set to a fixed value as described above based on the assumption that the heater **131***a* is at room temperature or near room temperature, and therefore, the resistance of the heater **131***a* has reached a minimum value.

Further, the inrush current flowing into the heater **131***a* tends to be greater when the zero-crossing control activation method is employed compared to when the phase control activation method is employed, as already described above. As such, when comparing the correction coefficients for the same duration of the immediately preceding non-activation period in the two tables, it can be seen that the correction coefficient in table A indicates a greater value than the corresponding correction coefficient in table B.

The CPU**161**, as already described above, performs the heater power estimation as described in the following for estimating the power consumption level of the heater **131***a* by using the correction table A, the correction table B, and the basic power consumption level of the heater **131***a*.

(1-6) Details of Heater Power Estimation

In the following, description is provided on the heater power estimation executed by the control unit **6**, with reference to the flowchart in FIG. **7**.

The CPU **161** determines whether or not a specification of the activation method of the heater **131***a* has been received via the operation panel **7** (Step S**11**).

When a specification of the activation method of the heater **131***a* has been received (Step S**11**: YES), the CPU **161** determines whether or not the activation method specification of which is received is the zero-crossing control activation method (Step S**12**). When a specification is made of the zero-crossing control activation method (Step S**12**: YES), the CPU **161** sets zero as the value of a flag M stored in the EEPROM **165**, and sets **20** to an index value n that indicates the duration of the initial activation period (Step S**13**). Here, note that the flag M indicates the currently-specified activation method. In addition, correction of the power consumption level of the heater **131***a* is performed during the initial activation, period. Further, the CPU **161** determines whether or not a timing has arrived at which the heater **131***a* is to be deactivated (Step S**14**).

On the other hand, when a specification is made of the phase control activation method and not the zero-crossing control activation method (Step S**12**: NO), the CPU **161** sets one as the value of the flag M stored in the EEPROM **165**, sets 70 to the index value n (Step S**15**), and executes the processing in Step S**14** and on.

Further, when a specification of the activation method of the heater **131***a* is not received, or that is, when the activation method of the heater **131***a* has not been changed (Step S**11**: NO), the CPU **161** executes the processing in Step S**14** and on.

As already described above, the CPU **161** determines whether or not the timing has arrived at which the heater **131***a* is to be deactivated in Step S**14**. When determining that the timing has arrived at which the heater **131***a* is to be deactivated (Step S**14**: YES), the CPU **161** terminates the output of the heater activation signal to the triac **154**, and thereby deactivates the heater **131***a*. In addition, the CPU **161** causes the timer **162** to commence measurement of time (Step S**16**), and then determines whether or not a timing has arrived at which the heater **131***a* is to be activated (Step S**17**).

On the other hand, when the timing has not arrived at which the heater **131***a* is to be deactivated (Step S**14**: NO), the CPU **161** executes the processing in Step S**17** and on (Step S**14**: NO).

When the timing has arrived at which the heater **131***a* is to be activated (Step S**17**: YES), the CPU **161** causes the timer **162** to terminate the measurement of time, obtains the time measured by the timer **162**, and sets the time as a duration tf of the immediately preceding non-activation period (Step S**18**). In addition, the CPU **161** determines whether or not the flag M indicates zero (Step S**19**).

When the flag M indicates zero (Step S**19**: YES), the CPU **161** commences the activation of the heater **131***a* according to the zero-crossing control activation method (Step S**20**), and determines whether or not the duration tf of the immediately preceding non-activation period is greater than a predetermined duration ta (0.2 seconds in this example) (Step S**21**).

When the duration tf of the immediately preceding non-activation period is extremely short, or that is, when the duration tf of the immediately preceding non-activation period satisfies $tf \leq ta$ (threshold value), the state of the heater

131*a* is regarded as being similar to that when being continuously activated, and hence, it is regarded that the inrush current need not be taken into consideration. As such, the CPU **161** skips a later-described count-up processing (Step S**23**), which is to be executed at a point following the activation of the heater **131***a* when the inrush current occurs, and jumps to the later-described processing in Step S**24**.

On the other hand, when the flag M does not indicate zero, or that is, when the flag M indicates one (Step S**19**: NO), the CPU **161** commences the activation of the heater **131***a* according to the phase control activation method (Step S**22**), and determines whether or not the duration tf of the immediately preceding non-activation period is greater than the predetermined time period ta (Step S**21**).

When the duration tf of the immediately preceding non-activation period greater than the predetermined time period ta (Step S**21**: YES), the CPU **161** commences the count-up processing described in the following.

(1-6-1) Count-Up Processing

In the process of conducting the above-described experiments, the present inventors found that (A) the amount of time, from the commencement of the activation of the heater **131***a*, required for the power consumption level of the heater **131***a* to stabilize, or that is, the initial activation period is longer when the phase control activation method is employed compared to when the zero-crossing control activation method is employed. In addition, the present inventors also found that (B) the initial activation period becomes longer when the heater **131***a* is activated and deactivated more frequently in response to the temperature adjustment control during the initial activation period.

(A) above is considered to be a result of the longer amount of time required for the temperature of the heater **131***a* to stabilize when the phase control activation method is employed. That is, when the phase control activation method is employed, the power level of the heater **131***a* is caused to rise more gradually, and hence, the temperature of the heater **131***a* rises at a relatively moderate rate compared to when the zero-crossing control activation method is employed. Such a difference in the rate at which the power level of the heater **131***a* increases between the two activation methods is a fundamental difference between the two methods, Further, (B) above is considered to be a result of the relatively small amount of heat generated by the heater **131***a* per unit time period when the heater **131***a* is activated in an intermittent manner. When the heater **131***a* generates a relatively small amount of heat per unit time period, a greater amount of time is required until a point is reached where the amount of heat generated by the heater **131***a* and the amount of heat dissipated by the heater **131***a* are balanced. This results in a greater amount of time being required until the temperature of the heater **131***a* stabilizes, which further results in a relatively long amount of time being required until the power consumption level of the heater **131***a* stabilized.

In view of the above, when it is desired to perform correction of the power consumption level of the heater **131***a*, it is necessary to determine whether or not the present point is within the initial activation period, during which the correction of the power consumption of the heater **131***a* is to be performed. The count-up processing that is described in detail in the following is processing for making this determination.

Here, note that the contents of the count-up processing slightly differ between the zero-crossing control activation method and the phase control activation method.

First, description is provided on the contents of the count-up processing in the zero-crossing control activation method, with reference to FIG. **3**.

While the heater activation signal is being output (i.e., from time point t**1** and on), the CPU **161** counts up by one from an initial value of zero each time a period corresponding to a half-cycle of the input voltage V_I (i.e., the period from t**1** to t**2** in FIG. **3**, or 0.01 seconds in this example) elapses. Further, when this count-up value reaches the value n (n=20) defined in Step S**13** (time point t**3**), the CPU **161** determines that a transition from the initial activation period to the stable activation period has taken place.

The determination is made in such a manner since, in the zero-crossing control activation method, a value indicating the magnitude of the inrush current and the time required until the inrush current diminishes is greatest when power supply to the heater **131***a* is commenced following an immediately preceding non-activation period having a duration of 600 seconds or longer, and the time required until the inrush current substantially disappears in such a case corresponds to n=20.

As already described above, when the output of the heater activation signal is suspended for a period shorter than 0.2 seconds before the stable activation period is reached, the heater **131***a* is regarded as being continuously in the activation state. However, it should be noted that the count-up processing is suspended in such a case, which results in the initial activation period being extended compared to when such a suspension does not take place.

The following explains the reasons as to why the length of the initial activation period is changed according to the total amount of time during which the heater **131***a* is in the activation state.

That is, the above-described count-up value indicates the number of waveform sections corresponding to a half-cycle of the input voltage (the darkly shaded sections), as illustrated in FIG. **3**, and the number of such waveform sections indicates, to some extent, the amount of power having been supplied to the heater **131***a* and the amount of heat (temperature) provided to the heater **131***a* since the commencement of the activation of the heater **131***a*.

That is, the length of the initial activation period is changed according to the total amount of time during which the heater **131***a* is activated based on the conception that the heater **131***a* is provided with a greater amount of heat when the heater **131***a* is continuously activated for a great amount of time. When the heater **131***a* is continuously in the activation state for a longer time and more heat is provided to the heater **131***a*, the temperature of the heater **131***a* indicates a greater increase per unit time period, and the point where the amount of heat generated by the heater **131***a* and the amount of heat dissipated by the heater **131***a* is balanced is reached in a shorter time. As such, the resistance of the heater **131***a* stabilizes in a shorter amount of time, and further, the power consumption level of the heater **131***a* stabilizes in a shorter amount of time.

In addition, in FIG. **3**, the period between time point t**5** and time point t**6** is indicated as not corresponding to the initial activation period even though the activation of the heater **131***a* is commenced at time point t**5**. This is since, the duration (time point t**5**-time point t**4**) of the immediately preceding non-activation period preceding this period is shorter than 0.2 seconds, and further since the period between time point t**3** and time point t**4** corresponds to the stable activation period, and therefore, it can be regarded that the increase in the power consumption level of the heater **131***a* brought about by the inrush current during the period between time point t**5** and time point t**6** need not be taken into consideration (corresponds to the processing in Step S**21** in FIG. **7**).

Subsequently, description is provided on the contents of the count-up processing in the phase control activation method, with reference to FIG. **4**.

The basic idea underlying the count-up processing in the phase control activation method is similar to that of the count-up processing in the zero-crossing control activation method. However, the count-up processing performed in the phase control activation method differs from that performed in the zero-crossing control activation method in terms of how the count-up is performed and the above-described value n. Such differences arise from the difference in the pattern in which the heater activation signal is output in the two activation methods.

In specific, during the heating period of the heater **131***a* when the phase control activation method is employed, the CPU **161** counts up by one from an initial value of zero each time each time a total area of the waveform of the voltage applied to the heater **131***a* (the darkly shaded sections in FIG. **4**) equals a multiple of an area corresponding to a half-cycle of the input voltage V_I.

Similar as in the zero-crossing control activation method, the above-described count-up value indicates, to some extent, the amount of power supplied to the heater **131***a* and the amount of heat (temperature) provided to the heater **131***a* since the commencement of the activation of the heater **131***a*.

Further, when this count-up value reaches the value n (n=70) defined in Step S**15** (i.e., t**22**), the CPU **161** determines that a transition from the initial activation period to the stable activation period has taken place based on similar reasons as described above with respect to the zero-crossing control activation method.

The determination is made in such a manner since, in the phase control activation method, a value indicating the magnitude of the inrush current and the time required until the inrush current diminishes is greatest when power supply to the heater **131***a* is commenced following an immediately preceding non-activation period having a duration of 600 seconds or longer, and the time required until the inrush current substantially disappears in such a case corresponds to n=70.

Here, it should be noted that the printer **1**, when actually implemented, is not capable of directly detecting the voltage applied to the heater **131***a*. However, since the pattern in which the heater activation signal is output is determined in advance, the CPU **161** is able to determine in how many seconds from the commencement of the output of the heater activation signal a timing is reached for performing the count-up described above. As such, the CPU **161** executes the count-up processing by measuring the total amount of time during which power supply to the heater **131***a* is performed from the commencement of the activation of the heater **131***a*.

Note that, as already described above, in the phase control activation method, the conduction phase angle during which the triac **154** conducts (time corresponding to "ON" state) increases in a step-like manner until the duty ratio reaches 100% from 0%. In the present embodiment, the time point at which the duty ratio reaches 100% is set to coincide with the time point at which the value n reaches 70 (70 msec).

In addition, in FIG. **4**, the heating state corresponding to the period between time point t**24** and time point t**25** is not indicated as corresponding to the initial activation period even though the activation of the heater **131***a* is commenced at time point t. Similar as in the case of the period between time point t**5** and time point t**6** in FIG. **3**, this is since the duration of the immediately preceding non-activation period preceding this period is shorter than 0.2 seconds, and further since the period between time point t**22** and time point t**23** corresponds to the stable activation period.

As such, according to the present embodiment, the initial activation period is defined by using the above-described count-up value. Further, the power consumption level of the heater **131***a* during the initial activation period is calculated by (i) calculating a correction coefficient according to the duration of the immediately preceding non-activation period by referring to the correction table corresponding to the activation method being employed, and by (ii) multiplying the correction coefficient so calculated and the basic power consumption level of the heater **131***a* for the corresponding activation method.

Referring to FIG. **7** once again, the CPU **161** subsequently performs processing of estimating a value W_H indicating the power consumption level of the heater **131***a* and a value W_Hh indicating the energy consumption amount of the heater **131***a*, or that is, the CPU **161** performs the heater power estimation (Step S**24**). Such processing is described in detail later in the present disclosure.

In addition, at the same time as performing the heater power estimation, the CPU **161** performs, for each device included in the printer **1** other than the heater **131***a*, processing of estimating a power consumption level and an energy consumption amount (hereinafter referred to as "regular power consumption estimation") by assuming that power corresponding to a rated power level of the corresponding device is being consumed while power is being supplied thereto.

Further, the CPU **161** calculates a value W_{TH} indicating a power consumption level of the entire printer **1** by adding the value W_H indicating the power consumption level of the heater **131***a* to the values indicating the power consumption levels calculated through the regular power consumption estimation. Similarly, the CPU **161** calculates a value W_{TH}h indicating the energy consumption amount of the entire printer **1** by adding the value W_Hh indicating the energy consumption amount of the heater **131***a* to the values indicating the energy consumption amounts calculated through the regular power consumption estimation.

In addition, the CPU **161** calculates the maximum power consumption level of the entire printer **1** as described in the following and displays the result of the calculation on the operation panel **7** (Step S**25**).

That is, the CPU **161** temporary stores the value indicating the power consumption level of the entire printer **1** to the EEPROM **165**. Then, when a subsequent estimation is performed of the value indicating the power consumption level of the entire printer **1** and the newly-estimated value indicating the power consumption level of the entire printer **1** is greater than the value indicating the power consumption level of the entire printer **1** stored in the EEPROM **165**, the CPU **161** replaces the value indicating the power consumption level of the entire printer **1** stored in the EEPROM **165** with the newly-estimated value indicating the power consumption level of the entire printer **1**. As such, the CPU **161** estimates the maximum power consumption level of the entire printer **1**. Such processing is hereinafter referred to as "maximum power consumption level estimation".

The regular power consumption estimation and the maximum power consumption level estimation are performed in units of months, and the CPU **161** causes the operation panel **7** to display the results of such estimation for each month.

FIG. **8** illustrates an example of display performed by the operation panel **7**.

As illustrated in FIG. **8**, a maximum power consumption level display field **206** displays the maximum power consumption level of the printer **1** for each month, for instance, from August to November, which is the current month. Note that the maximum power consumption level for the current month displayed in the maximum power consumption level display field **206** indicates the maximum power consumption level of the printer **1** up to present point. In addition, an energy consumption amount display field **205** displays the energy consumption amount of the printer **1** for each month, for instance, from August to November, which is the current month. Note that the energy consumption amount for the current month displayed in the energy consumption amount display field **205** indicates the energy consumption amount of the printer **1** up to the present point.

Note that the operation panel **7** displays, for each month, a total amount of time during which the printer **1** has been in a power-supplying state, a total amount of time during which the printer **1** has been in a standby state, a total amount of time during which the printer **1** has been in a power-saving state, and a total amount of time during which the printer **1** has been in an operation state. Each of such information is displayed in a corresponding one of fields **201**, **202**, **203**, and **204**.

Here, note that the operation state of the printer **1** is a state where the printer **1** is in the execution of a print operation. Therefore, the operation state indicates a state where the printer **1** is maintaining the surface temperature of the fixing roller **131** at the fixing temperature while causing a recording sheet to pass through the fixing nip in the fixing unit **30**. Further, during the operation state of the printer **1**, power is supplied to the exposure unit **17** in each of the imaging units **11**Y through **11**K, the undepicted drive source of the photosensitive drum **12** in each of the imaging units **11**Y through **11**K, the heater **131***a*, etc.

The standby state of the printer **1** is a state where the printer **1** is waiting for a print job to be executed while supplying power to the heater **131***a* and thereby maintaining the surface temperature of the fixing roller **131** at the fixing temperature.

Further, the power-saving state of the printer **1** is, for instance, a state in which the printer **1**, by maintaining the surface temperature of the fixing roller **131** at an intermediate temperature between the fixing temperature and room temperature, reduces power consumption while reducing the time required for completion of a warm-up operation that is to be commenced when a print job is received.

In addition, the power-supplying state of the printer **1** as described above refers to a combination of the operation state, the standby state, and the power-saving state of the printer **1**. As such, a sum of the total amount of time of the operation state, the total amount of time of the standby state, and the total amount of time of the power-saving state equals the total amount of time of the power-supplying state of the printer **1**.

The amount of time during which the printer **1** is in each of the operation state, the standby state, and the power-saving state is measured by the timer **162**, and values indicating such time amounts are stored to the EEPROM **165** by the CPU **161**.

Returning to FIG. **7** once again, the CPU **161** subsequently determines whether or not an instruction for deactivation of the printer **1** (an instruction for turning the power of the printer **1** off) has been received (Step S**26**). When an instruction for deactivation of the printer **1** has been received (Step S**26**: YES), the CPU **161** terminates the heater power estimation.

On the other hand, when an instruction for deactivation of the printer **1** has not been received (Step S**26**: NO), the CPU **161** repeats the processing in Step S**14** and on.

Note that, when determined in Step S**17** that the timing at which the heater **131***a* is to be activated has not arrived (Step S**17**: NO), the CPU **161** executes the processing in Step S**24** and on.

In the following, description is provided on the heater power estimation.

(1-6-2) Heater Power Estimation

FIG. **9** is a flowchart illustrating a subroutine (the heater power estimation) corresponding to Step S**24** in FIG. **7**.

The CPU **161** checks the state of output of the heater activation signal and thereby determines whether or not the heater **131***a* is in activation state at the present point (Step S**31**).

When the heater **131***a* is not in activation state at the present point (Step S**31**: NO), the CPU **161** skips to the processing in Step S**25** in FIG. **7**.

On the other hand, when the heater **131***a* is in activation state at the present point (Step S**31**: YES), the CPU **161** determines whether or not the count-up value is smaller than or equal to the value n at the present point (Step S**32**). When the count-up value is not smaller than or equal to the value n (Step S**32**: NO), the CPU **161** terminates the count-up processing (Step S**33**), assumes that the value W_{HS} indicating the rated power level of the heater **131***a* corresponds to the value W_H indicating the power consumption level of the heater **131***a* (Step S**34**), and calculates the value W_Hh indicating the energy consumption amount up to the present point by multiplying the value W_H indicating the power consumption level and a value h indicating a duration for which power has been supplied to the heater **131***a* (Step S**35**). Further, the CPU **161** updates the energy consumption amount stored in the EEPROM **165** by adding the currently-calculated value W_Hh indicating the energy consumption amount of the heater **131***a* to the previously-calculated value W_Hh stored in the EEPROM **165** (Step S**36**).

On the other hand, when the count-up value is equal to or smaller than the value n (Step S**32**: YES), and further, when determining that the value of the flag M indicates zero (Step S**37**: YES), the CPU **161** selects and refers to the correction table A corresponding to the zero-crossing control activation method (Step S**38**) and thereby obtains a correction coefficient corresponding to the duration of the immediately preceding non-activation period (Step S**39**). Further, the CPU **161** regards a value W_H calculated by multiplying a value W_{HB} indicating the basic power consumption level of the heater **131***a* corresponding to the present activation method and the correction coefficient as the power consumption level of the heater **131***a* (Step S**40**), and executes the processing in Step S**35** and on.

In addition, when the count-up value is equal to or smaller than the value n (Step S**32**: YES), and further, when determining that the value of the flag M does not indicate zero (Step S**37**: NO), the CPU **161** selects the correction table B corresponding to the phase control activation method (Step S**41**), and executes the processing in Step S**39** and on.

For instance, when a heater having a rated power level of 900 W is activated according to the zero-crossing control activation method, is then deactivated and kept in the non-activation state for 0.2 seconds (i.e., the duration of the immediately preceding non-activation period is 0.2 seconds), and subsequently reactivated, the CPU **161** refers to "0.2 seconds or longer and shorter than 0.5 seconds" in a corresponding one of columns **221**, which indicate durations of the immediately preceding non-activation period, in the correction table A in FIG. **6**A and obtains a value 1.20 in a corresponding one of columns **222**, which indicate correction coefficients corresponding to the durations.

As such, the CPU **161** performs an estimation such that the actual power consumption level of the heater is 1080 W, which is a value calculated by multiplying 900 W, which is the basic power consumption level (i.e., the rated power level) of the heater, by the correction coefficient 1.20 obtained from the correction table A.

On the other hand, when a heater having the same specifications as above is activated according to the phase control activation method, the CPU **161** refers to "0.2 seconds or longer and shorter than 0.5 seconds" in a corresponding one of columns **231**, which indicate durations of the immediately preceding non-activation period, in the correction table B in FIG. **6**B and obtains a value 1.10 in a corresponding one of columns **232**, which indicate correction coefficients corresponding to the durations.

In the meantime, although not illustrated in FIG. **6**B, the basic power consumption level of the heater, when activated according to the phase control activation method, is regarded as being 600 W.

As such, the CPU **161** performs an estimation such that the actual power consumption level of the heater is 660 W, which is a value calculated by multiplying 600 W, which is the basic power consumption level of the heater, by the correction coefficient 1.10 obtained from the correction table B.

As description has been provided up to this point, in embodiment 1, when a power consumption level of a heater is to be estimated, a correction coefficient is determined in accordance with a duration of an immediately preceding non-activation period, and the power consumption level of the heater is calculated by multiplying a power consumption level of the heater during an initial activation period by the correction coefficient. As such, the power consumption level of the heater can be accurately estimated without the use of a wattmeter or the like, which is expensive and therefore brings about an increase in device cost.

(2) Embodiment 2

(2-1) Structure of Image Forming Apparatus

In the following, description is provided on a printer that is one example of an image forming apparatus pertaining to embodiment 2 of the present invention.

A printer **1** pertaining to embodiment 2 has a structure basically similar to that of the printer **1** pertaining to embodiment 1. However, heater power estimation performed by the CPU **161** in the printer **1** pertaining to embodiment 2 differs in part from the heater power estimation performed by the CPU **161** in the printer **1** pertaining to embodiment 1. Further, the ROM **163** in the printer **1** pertaining to embodiment 2 stores, in addition to the correction tables A and B stored by the ROM **163** in the printer **1** pertaining to embodiment 2, correction tables C and D. The printer **1** pertaining to embodiment 2 differs from the printer **1** pertaining to embodiment 2 in such aspects.

In the following, constituent elements common between the printer **1** pertaining to embodiment 1 and the printer **1** pertaining to embodiment 2 are referred to by using the same reference signs and description thereon is omitted. As such, description is provided while mainly focusing on differences between the printer **1** pertaining to embodiment 1 and the printer **1** pertaining to embodiment 2.

The present inventors conducted a test and the like to evaluate the accuracy of the estimation of the power consumption level of the heater **131***a* through the execution of the heater power estimation in the printer **1** pertaining to embodiment 1.

As a result, the present inventors found that the power consumption level of the heater **131***a* estimated through the heater power estimation slightly differs from an actually-measured power consumption level of the heater **131***a* within a predetermined period from the commencement of the activation of the printer **1** in certain situations. More specifically, a difference was observed between the estimated power consumption level and the actually-measured power consumption level (i) when the activation of the heater **131***a* was commenced at a point when the printer **1** recovered from a long-period sleep state and (ii) when the activation of the heater **131***a* was commenced at a point when the printer **1** commenced a warm-up operation upon activation thereof (i.e., upon turning on of power of the printer **1**). Here, note that a long-period sleep state refers to a state where the printer **1** is in a sleep mode where power supply to most devices in the printer **1** is disabled for a period of 60 minutes or longer.

The above-described predetermined period, where the difference between the power consumption levels of the heater **1** is observed was, for instance, around five minutes in the printer **1** pertaining to embodiment 1, but may differ depending upon factors such as the heat capacity of the heater **131***a* and the heat capacity of other members located around the heater **131***a*.

The above-described difference between the estimated power consumption level of the heater **131***a* and the actually-measured power consumption level of the heater **131***a* is considered as being a result of the rate of increase of the temperature of the heater **131***a* decreasing due to heat being conducted away from the heater **131***a* when the activation of the heater **131***a* is commenced according to the same activation patterns as described in embodiment 1 at a point when the printer **1** is activated or at a point when the printer **1** recovers from the long-period sleep state. In such cases, heat is conducted away from the heater **131***a* by the members located around the heater **131***a* whose temperature has not yet reached an appropriate level due to the temperature of the entire fixing unit **30** having dropped to near room temperature.

(2-2) Method for Correcting Power. Consumption Level of Heater When Activated Upon Activation of Printer or Upon Recovery of Printer from Long-period Sleep State

For each of the two activation methods of the heater **131***a*, the present inventors measured the power consumption level of the heater **131***a* when activated upon the activation of the printer **1** and when activated upon the recovery of the printer **1** from the long-period sleep state, for the accuracy of the estimation of the power consumption level of the heater **131***a* decreases in such cases as already described above. Further, the present inventors prepared a correction table C for the zero-crossing control activation method and a correction table D for the phase control activation method according to values obtained through the measurement. The printer **1** pertaining to embodiment 2 is capable of estimating the power consumption level of the heater **131***a* with higher accuracy by selecting and thereby using an appropriate one of such tables when performing the correction of the power consumption level of the heater **131***a* in cases where the heater **131***a* is activated upon the activation of the printer **1** or upon the recovery of the printer **1** from the long-period sleep state.

In specific, the present inventors additionally stored the correction tables B and C corresponding to embodiment 2 to the ROM **163**, and further, modified the contents of the subroutine performed in Step S**24** in FIG. **7**.

FIG. **10**A illustrates the contents of the correction table C, and FIG. **10**B illustrates the contents of the correction table D.

As can be seen when referring to FIGS. **10**A and **10**B, the correction coefficient is set to 1.05 when the duration of the immediately preceding non-activation period is shorter than 0.2 seconds, regardless of whether the zero-crossing control activation method or the phase control activation method is employed. That is, it is regarded that the inflow of the inrush current is not completely inhibited even when power is being continuously supplied to the heater **131***a*.

As such, in embodiment 1, the determination in Step S**21** in FIG. **7** is not performed, and hence, the count-up processing corresponding to Step S**23** is performed in all cases.

Further, for each of the two activation methods of the heater **131***a*, the correction coefficient corresponding to a duration of the immediately preceding non-activation period of 0.2 seconds or longer indicates a slightly greater value than the corresponding correction coefficient in embodiment 1.

This is considered as being a result of the increase of the temperature of the heater **131***a* being suppressed as described above when the activation of the heater **131***a* is commenced when the printer **1** is activated or when the printer **1** recovers from the long-period sleep state, which results in the resistance of the heater **131***a* decreasing and inrush current having a relatively great magnitude occurring upon activation of the heater **131***a*. More specifically, as described above, the increase of the temperature of the heater **131***a* is suppressed when the activation of the heater **131***a* is commenced when the printer **1** is activated or when the printer **1** recovers from the long-period sleep state since, when the activation of the heater **131***a* is commenced according to the same activation patterns as described in embodiment 1 in such cases, heat is conducted away from the heater **131***a* by the members located around the heater **131***a* whose temperature has not yet reached an appropriate level due to the temperature of the entire fixing unit **30** having dropped to near room temperature.

Note that the correction coefficients in the correction tables C and D have been calculated in a similar manner as the correction coefficients in the correction tables A and B. That is, the correction coefficients have been calculated by conducting the above-described experiments and by performing a calculation of dividing an energy consumption amount of the heater **131***a* actually measured during a corresponding one of (i) a period from the activation of the heater **131***a* to the termination of the initial activation period and (ii) a period from the recovery of the printer **1** from the long-period sleep state to the termination of the initial activation period by the basic energy consumption amount of the heater **131***a* during the initial activation period. As described above, the basic energy consumption amount of the heater **131***a* is the energy consumption amount of the heater **131***a* that is determined under a situation where the activation of the heater **131***a* is commenced according to the stable activation conditions as described above where the inrush current does not substantially occur.

Note that, when the duration of the immediately preceding non-activation period is 600 seconds or longer, or that is, when the heater **131***a* is activated after continuously being in the non-activation state for ten minutes or longer, the correction coefficient is set to a fixed value for each of the activation modes (namely, 4.20 for the zero-crossing control activation method and 2.10 for the phase control activation method), similar as in embodiment 1.

This is since the temperature of the heater **131***a* equals or is around room temperature when the duration of the immediately preceding non-activation period is 600 seconds or longer.

FIG. **11** is a flowchart illustrating a new subroutine executed in place of steps surrounded by chained double-dashed lines in FIG. **9** by the control unit **6** in embodiment 2.

When determining that the initial activation period is still continuing in the determination in Step S**32** in FIG. **9** (Step S**32**: YES), the CPU **161** makes a determination of whether a time period tp is equal to or shorter than a predetermined time period tb. Here, the time period tp is a time period from when the printer **1** has been activated or from when the printer **1** has recovered from the long-period sleep state.

When the time period tp is not equal to or shorter than the predetermined time period tb (here, tb is set to five minutes), or that is, when the heater **131***a* has been activated under the same conditions as in embodiment 1, the CPU **161** performs the heater power estimation similar as in embodiment 1.

That is, the CPU **161**, when the value of the flag M indicates zero (Step S**51**: YES), selects the correction table A (Step S**52**), and executes the processing in Step S**39** and on in FIG. **9**.

On the other hand, when the value of the flag M does not indicate zero (Step S**51**: NO), the CPU **161** selects the correction table B (Step S**41**), and executes the processing in Step S**39** and on.

In contrast, when the time period tp is equal to or shorter than the predetermined time period tb (here, tb is set to five minutes), the CPU **161** determines whether the value set to flag M indicates zero. When the value set to flag M indicates zero, or that is, when the flag M indicates the zero-crossing control activation method (Step S**54**: YES), the CPU **161** sets **50** as the value n indicating the length of the initial activation period, selects the correction table C (Step S**56**), and executes the processing in Step S**39** and on in FIG. **9**.

On the other hand, when the value set to flag M does not indicate zero, or that is, when the flag M indicates the phase control activation method (Step S**54**: NO), the CPU **161** selects the correction table D (Step S**57**), and executes the processing in Step S**39** and on in FIG. **9**.

Here, a new value of **50** is set to the value n indicating the length of the initial activation period only in the zero-crossing control activation method. This is since, through the above-described experiments, the present inventors found that the period from the commencement of the activation of the heater **131***a* to when the power consumption of the heater **131***a* becomes stable, or that is, the initial activation period increases only when the zero-crossing control activation method is employed.

The following can be considered as reasons for this.

By the time the printer **1** is activated after being deactivated once or the printer **1** recovers from being in the long-period sleep state, the temperature of the heater **131***a* and the members of the printer **1** located around the heater **1** have dropped to near room temperature.

Here, the members of the printer **1** located around the heater **131***a* refer to the fixing roller **131**, the pressurizing roller **132**, an undepicted housing that surrounds the fixing unit **30**, etc.

Even when the activation of the heater **131***a* is commenced upon the activation of the printer **1** or upon the recovery of the printer **1** from the long-period sleep state and the temperature of the filament of the heater **131***a* rises (to around two thousand and several hundred degrees), a certain amount of time (i.e., the predetermined time period tb) is required for the amount of heat generated by the heater **131***a* and the amount of heat dissipated by the heater **131***a* to balance. This is due to the heat capacity of the above-described members located around the heater **1**.

Further, as illustrated in FIG. **6**, among the two activation methods of the heater **1**, the zero-crossing control activation method, due to its nature, tends to bring about a greater inrush current than the phase control activation method.

As such, when the time period tp is shorter than the predetermined time period tp in the zero-crossing control activation method, a relatively great amount of time is required until the power consumption level of the heater **131***a* stabilizes. This is since, the temperature of the members located around the heater **131***a* is still low when the heater **131***a* is put in activation state, and hence such members conduct heat away from the heater **131***a*, which results in the temperature of the heater **131***a* in activation state being lower than appropriate. Due to this, inrush current of even greater magnitude flows into the heater **131***a*, and a relatively great amount of time is required until the power consumption level of the heater **131***a* stabilizes.

In contrast, when the phase control activation method is employed, the amount of power supplied to the heater **131***a* increases gradually. Therefore, due to the fundamental characteristics of the phase control activation method, the inrush current occurring has a smaller magnitude compared to when the zero-crossing control activation method is employed. As such, the magnitude of the inrush current does not increase by much, and therefore, it can be assumed that the time required for the power consumption level of the heater **131***a* to stabilize is not so long compared to when the zero-crossing control activation method is employed.

As description has been provided up to this point, in embodiment 2, when a power consumption level of a heater is to be estimated, a correction coefficient is determined in accordance with a duration of an immediately preceding non-activation period and a time period elapsing from the recovery of the printer from the long-period sleep state or the activation of the printer, and the power consumption level of the heater is calculated by multiplying a power consumption level of the heater during an initial activation period by the correction coefficient. As such, the power consumption level of the heater can be accurately estimated without the use of a watt-meter or the like, which is expensive and therefore brings about an increase in device cost.

<Modifications>

The present invention is not limited to such embodiments as described above, and modifications as described in the following can be made without departing from the spirit and the scope of the present invention.

(1) In the embodiments, description is provided that the operation panel **7** displays the power consumption level of the entire printer **1**, the energy consumption amount of the entire printer **1**, and the maximum power consumption level of the entire printer **1** in units of months. However, the present invention is not limited to this, and the operation panel **7** may display any information provided that the information is at least based on the power consumption level of the heater **131***a*.

Further, such information based on the power consumption level of the heater **131***a* may be, for instance, output to an external personal computer, etc,. via the communication I/F unit **166**.

In addition, when the printer **1** is provided with a speaker of a like, such information based on the power consumption level of the heater **131***a* may be output in the form of sound. In short, information based on the power consumption level of the heater **131***a* may be output in any form that allows a user to recognize such information.

(2) In the embodiments, the time period tp indicating the time period elapsing from the activation of the printer **1** or the recovery of the printer **1** from the long-period sleep state has been used as a value indicating a surrounding temperature of the heater **131***a*, and the estimation of the power consumption level of the heater **131***a* is performed by selecting one of the correction tables C and D, which are not normally used, according to the time period tp. However, the present invention is not limited to this.

For instance, a temperature sensor for measuring an atmospheric temperature inside the fixing unit **30** may be provided, and the estimation of the power consumption level of the heater **131***a* may be performed by using the correction tables C and D when the temperature inside the fixing unit **30** measured by the temperature sensor is equal to or lower than a predetermined temperature. That is, a determination to use one of the correction tables C and D may be made by acquiring a value indicating a surrounding temperature of the heater **131***a* and when the value is equal to or smaller than a predetermined value.

(3) In the embodiments, the operation panel **7** is described as one example of a component that receives a selection of the activation method of the heater **131***a*. However, the present invention is not limited to this, and the selection of the activation method of the heater **131***a* may be received from an external personal computer via the communication I/F unit **166**.

(4) In the embodiments, description is provided based on the presumption that the only component whose power consumption level needs to be estimated while taking into account the influence of the inrush current is the heater **131***a*. However, the present invention is not limited to this, and the estimation of power consumption level may be performed while taking into consideration the influence of the inrush current for components such as one or more motors driving the rollers included in the printer **1** to rotate.

(5) In the embodiments, in the phase control activation method, the triac **154** is controlled to conduct such that the time point at which the duty ratio reaches 100% is set to coincide with the time point at which the value n reaches 70 (i.e., 70 msec). However, the present invention is not limited to this, and the initial activation period need not be set so as to be exactly equal to the time period during which the duty ratio is changed to reach 100% from 0%. The time point required for the duty ratio to reach 100% may be any time point before the time point at which the initial activation period terminates.

This is since, regardless of which of the two activation methods is employed, it is regarded that power corresponding to the rated power level of the heater **131** is consumed during the stable activation period, and therefore, it suffices to stabilize the power consumption level of the heater **131***a* before the initial activation period terminates.

(6) In the embodiments, the fixing roller and the pressurizing roller are pressed against each other so as to form a fixing nip. However, the present invention is not limited to this.

For instance, a pressurizing pad having a surface covered with low friction material may be pressed against the fixing roller instead of the pressurizing roller. In short, any member may be used as the pressurizing member for applying pressure onto the fixing roller provided that the member is capable of applying pressure onto the fixing roller while having an appropriate level of slidability at a surface thereof.

(7) In the embodiments, description is provided on an example where the image forming apparatus pertaining to the present invention is implemented as a tandem-type color digital printer. However, the present invention is not limited to this, and the image forming apparatus pertaining to the present invention may be implemented, for instance, as a monochrome printer. That is, the present invention is applicable to image forming apparatuses including fixing devices in general.

In addition, the present invention may be any combination of the embodiments and the modifications described up to this point.

Although the present invention has been fully described by way of examples with reference to the accompanying drawings, it is to be noted that various changes and modifications will be apparent to those skilled in the art. Therefore, unless such changes and modifications depart from the scope of the present invention, they should be construed as being included therein.

What is claimed is:

1. An image forming apparatus having a fixing unit that includes a pressurizing member, a heating rotational body, and a heater, wherein the fixing unit adjusts a temperature of the heating rotational body by switching a state of the heater between a heating state where the heater receives power supply and a non-heating state where the heater does not receive power supply, and the fixing unit, when a recording sheet having an unfixed toner image formed thereon passes through a fixing nip formed between the heating rotational body and the pressurizing member by the pressurizing member pressing against the heating rotational body, heat-fixes the toner image onto the recording sheet, the image forming apparatus comprising:

a storage unit that stores a basic energy consumption rate of the heater determined in advance in a situation where the heater is in the heating state and where inflow of inrush current to the heater is not occurring;

an estimation unit that calculates an estimated energy consumption rate of the heater by (i) estimating, according to a duration of a non-heating state immediately preceding the heating state, an increase in the energy consumption rate of the heater, with respect to the basic energy consumption rate of the heater, brought about by inflow of inrush current to the heater occurring when the heater is switched from the immediately preceding non-heating state to the heating state, and (ii) adding the increase in the energy consumption rate of the heater to the basic energy consumption rate of the heater; and

an output unit that outputs the estimated energy consumption rate of the heater.

2. The image forming apparatus of claim **1**, wherein

the storage unit stores, in addition to the basic energy consumption rate of the heater, a table that associates, in one-to-one correspondence, durations of the non-heating state with values of the increase in the energy consumption rate of the heater, and

the estimation unit

includes a time measuring subunit that measures the duration of the immediately preceding non-heating state, which commences when the switching is performed while the heater is in a previous heating state and terminates when the heater is switched to the heating state, and

estimates the increase in the energy consumption rate of the heater according to the duration of the immediately preceding non-heating state, which is measured by the time measuring subunit, and by referring to the table stored in the storage unit.

3. The image forming apparatus of claim **2** further comprising

an acquisition unit that acquires a value indicating a surrounding temperature of the heating rotational body, wherein

the table comprises a first sub-table that corresponds to when the value indicating the surrounding temperature is equal to or greater than a predetermined value and a second sub-table that corresponds to when the value indicating the surrounding temperature is smaller than the predetermined value, and

the estimation unit estimates the increase in the power consumption rate of the heater by selecting, according to the value indicating the surrounding temperature, a corresponding one of the first sub-table and the second sub-table.

4. The image forming apparatus of claim **2**, wherein

the image forming apparatus is configured to selectively execute, as a function for controlling the power supplied to the heater during the heating state, one of a first function and a second function differing from the first function,

the table comprises two tables each corresponding to a different one of the first function and the second function, and

the estimation unit is configured to estimate the increase in the power consumption rate of the heater according to one of the two tables stored in the storage unit corresponding to the selected one of the first function and the second function.

5. The image forming apparatus of claim **3**, wherein

the values of the increase in the energy consumption rate of the heater, which are associated with the durations of the non-heating state, each indicate a greater value in the second sub-table than in the first sub-table.

6. The image forming apparatus of claim **3**, wherein

the acquisition unit estimates the value indicating the surrounding temperature of the heating rotational body according to the duration of the immediately preceding non-heating state.

7. The image forming apparatus of claim **1**, wherein

the estimation unit adds, to the basic energy consumption rate of the heater, the increase in the energy consumption rate of the heater during a period from when the heater is switched from the immediately preceding non-heating state to the heating state to when a duration of the heating state reaches a predetermined duration.

8. The image forming apparatus of claim **1**, wherein

the estimation unit estimates an amount of energy consumed by the heater according to the estimated energy consumption rate and a duration of a period during which power is supplied to the heater.

9. The image forming apparatus of claim **1**, wherein

the output unit is a display unit that displays information.

10. An image forming apparatus having a fixing unit that includes a pressurizing member, a heating rotational body, and a heater, wherein the fixing unit adjusts a temperature of the heating rotational body by switching a state of the heater between a heating state where the heater receives power supply and a non-heating state where the heater does not receive power supply, and the fixing unit, when a recording sheet having an unfixed toner image formed thereon passes through a fixing nip formed between the heating rotational body and the pressurizing member by the pressurizing member pressing against the heating rotational body, heat-fixes the toner image onto the recording sheet, the image forming apparatus comprising:

a storage unit that stores a basic energy consumption rate of the heater determined in advance in a situation where the heater is in the heating state and where inflow of inrush current to the heater is not occurring;

an estimation unit that estimates an energy consumption rate of the heater during an initial activation period by multiplying the basic energy consumption rate by a correction coefficient, the correction coefficient calculated in advance by dividing, by the basic energy consumption rate, an energy consumption amount during the initial activation period, the energy consumption amount including an increase brought about by inflow of inrush current to the heater occurring when the heater is switched from the immediately preceding non-heating state to the heating state; and

an output unit that outputs the estimated energy consumption rate of the heater.

11. The image forming apparatus of claim **10**, wherein

the storage unit stores, in addition to the basic energy consumption rate of the heater, a table that associates, in one-to-one correspondence, durations of the non-heating state with the correction coefficient, and

the estimation unit

includes a time measuring subunit that measures the duration of the immediately preceding non-heating state, which commences when the switching is performed while the heater is in a previous heating state and terminates when the heater is switched to the heating state, and

estimates the energy consumption rate of the heater during an initial activation period according to the duration of the immediately preceding non-heating state, which is measured by the time measuring subunit, and by referring to the table stored in the storage unit.

12. The image forming apparatus of claim **11**, further comprising

an acquisition unit that acquires a value indicating a surrounding temperature of the heating rotational body, wherein

the table comprises a first sub-table that corresponds to when the value indicating the surrounding temperature is equal to or greater than a predetermined value and a second subtable that corresponds to when the value indicating the surrounding temperature is smaller than the predetermined value, and

the estimation unit estimates the energy consumption rate of the heater during the initial activation period by selecting, according to the value indicating the surrounding temperature, a corresponding one of the first sub-table and the second sub-table.

13. The image forming apparatus of claim **11**, wherein

the image forming apparatus is configured to selectively execute, as a function for controlling the power supplied to the heater during the heating state, one of a first function and a second function differing from the first function,

the table comprises two tables each corresponding to a different one of the first function and the second function, and

the estimation unit is configured to estimate the energy consumption rate of the heater during the initial activation period according to one of the two tables stored in the storage unit corresponding to the selected one of the first function and the second function.

14. The image forming apparatus of claim **12**, wherein

the correction coefficient, which is associated with the durations of the non-heating state, indicates a greater value in the second sub-table than in the first sub-table.

15. The image forming apparatus of claim **12**, wherein

the acquisition unit estimates the value indicating the surrounding temperature of the heating rotational body according to the duration of the immediately preceding non-heating state.

16. The image forming apparatus of claim **10**, wherein

the estimation performs the estimation during a period from when the heater is switched from the immediately preceding non-heating state to the heating state to when a duration of the heating state reaches a predetermined duration.

17. The image forming apparatus of claim **10**, wherein

the estimation unit estimates an amount of energy consumed by the heater according to the energy consumption rate of the heater during the initial activation period and a duration of a period during which power is supplied to the heater.

18. The image forming apparatus of claim **10**, wherein

the output unit is a display unit that displays information.

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